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(12) **United States Patent**
Schwartz et al.

(10) **Patent No.: US 9,216,085 B2**
(45) **Date of Patent: Dec. 22, 2015**

(54) **PARTIAL JOINT RESURFACING IMPLANT, INSTRUMENTATION, AND METHOD**

(71) Applicant: **BIOPOLY, LLC**, Fort Wayne, IN (US)

(72) Inventors: **Herbert E. Schwartz**, Fort Wayne, IN (US); **Francis S. Proch**, Huntertown, IN (US); **Nathanael K. Conner**, Huntertown, IN (US)

(73) Assignee: **BIOPOLY, LLC**, Fort Wayne, IN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

(21) Appl. No.: **13/724,292**

(22) Filed: **Dec. 21, 2012**

(65) **Prior Publication Data**

US 2013/0184820 A1 Jul. 18, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/919,607, filed as application No. PCT/US2009/034826 on Feb. 23, 2009, now abandoned.

(60) Provisional application No. 61/032,141, filed on Feb. 28, 2008.

(51) **Int. Cl.**
A61F 2/30 (2006.01)
A61F 2/46 (2006.01) ***A61B 17/16*** (2006.01) ***A61B 17/17*** (2006.01)

(52) **U.S. Cl.**
CPC ***A61F 2/30756*** (2013.01); ***A61B 17/1635*** (2013.01); ***A61B 17/1675*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61F 2/30756; A61F 2/3872; A61F 2002/30766
USPC 623/14.12
See application file for complete search history.

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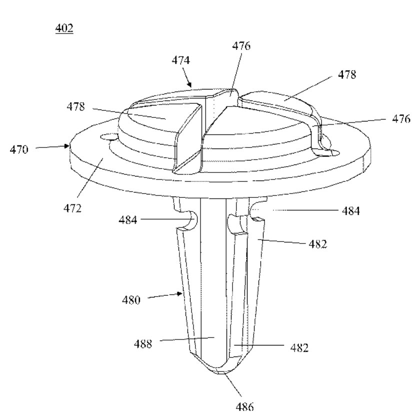
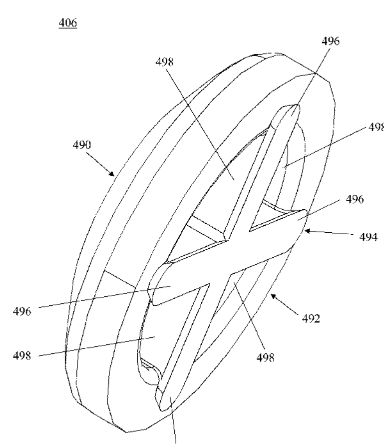
Primary Examiner — Thomas J Sweet
Assistant Examiner — Melissa Hoban
(74) *Attorney, Agent, or Firm* — Heslin Rothenberg Farley & Mesiti P.C.; John Boger

(57) **ABSTRACT**

A method of repairing an articular cartilage defect with the partial joint resurfacing implant includes surgically creating an opening in the articular cartilage defect site. The method also includes obtaining a partial resurfacing implant which is implanted into the opening. The partial resurfacing implant includes a top articulating portion, an implant fixation portion, and a locking mechanism. The implant fixation portion including an upper segment coupled to the top articulating portion and a bone interfacing segment configured to facilitate insertion into the articular cartilage defect site. The method further includes the bone interfacing segment being inserted into the opening with the top articulating portion and adjacent articular cartilage being positioned to each other to facilitate motion and load transfer over the defect site. Another method of repairing an articular cartilage defect with a partial joint resurfacing implant and a partial joint resurfacing implant are also disclosed.

20 Claims, 44 Drawing Sheets





(52) **U.S. Cl.**
CPC ***A61B17/1764*** (2013.01); ***A61F 2/4618*** (2013.01); ***A61F 2/4657*** (2013.01); ***A61F 2/4684*** (2013.01); *A61F 2002/30014* (2013.01); *A61F 2002/30065* (2013.01); *A61F 2002/3085* (2013.01); *A61F 2002/3096* (2013.01); *A61F 2002/30112* (2013.01); *A61F 2002/30125* (2013.01); *A61F 2002/30224* (2013.01); *A61F 2002/30299* (2013.01); *A61F 2002/30327* (2013.01); *A61F 2002/30331* (2013.01); *A61F 2002/30387* (2013.01); *A61F 2002/30759* (2013.01); *A61F 2002/30766* (2013.01); *A61F 2002/30878* (2013.01); *A61F 2002/30884* (2013.01); *A61F 2002/4662* (2013.01); *A61F 2002/4685* (2013.01); *A61F 2310/00407* (2013.01); *A61F 2310/00796* (2013.01); *A61F 2310/00976* (2013.01)

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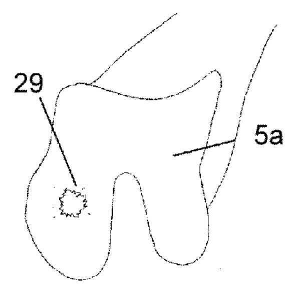
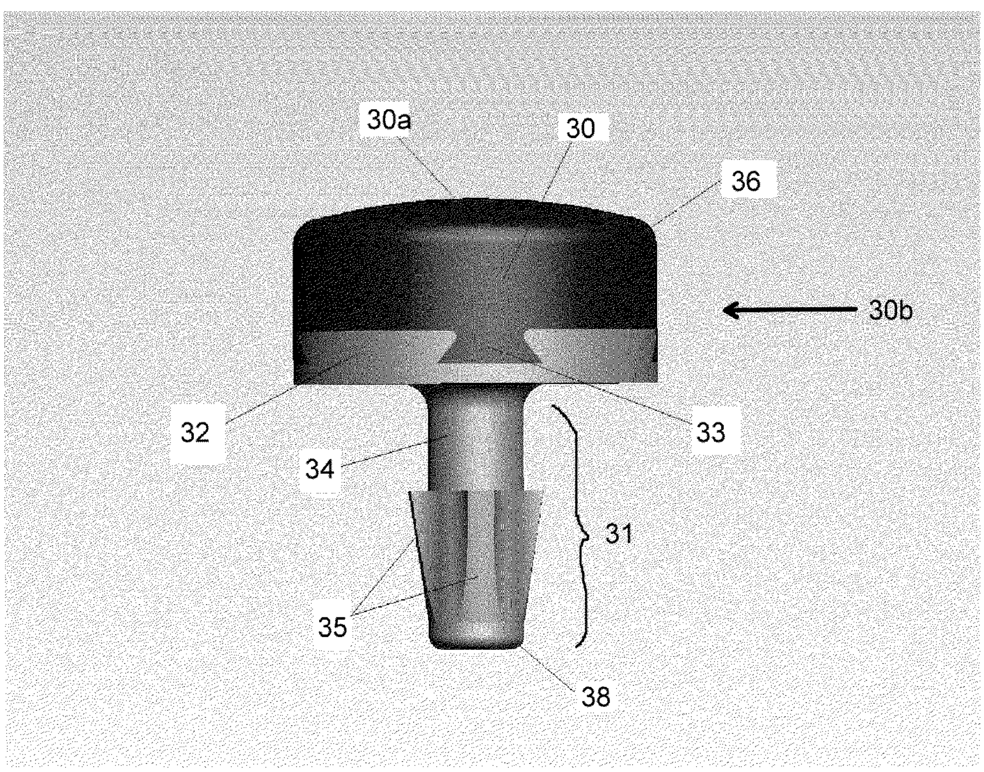


FIG. 1



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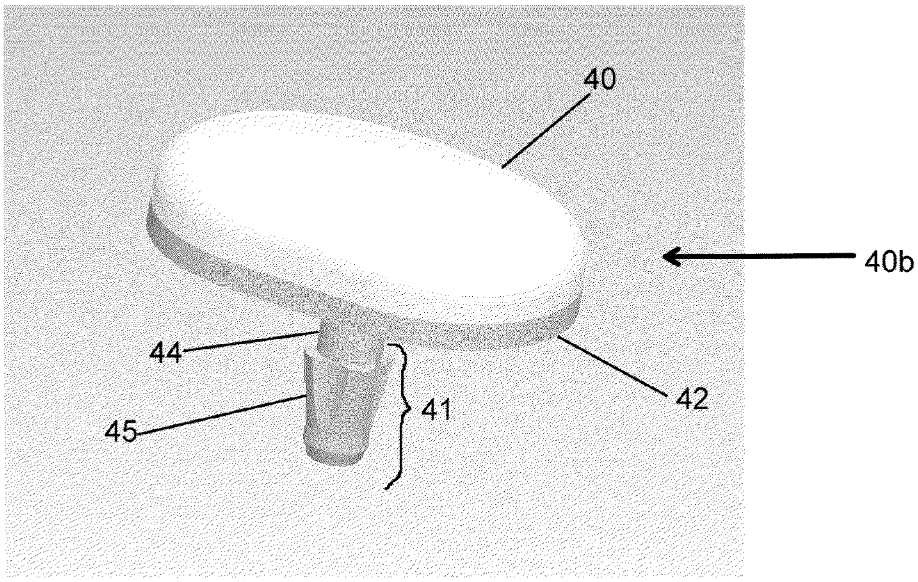

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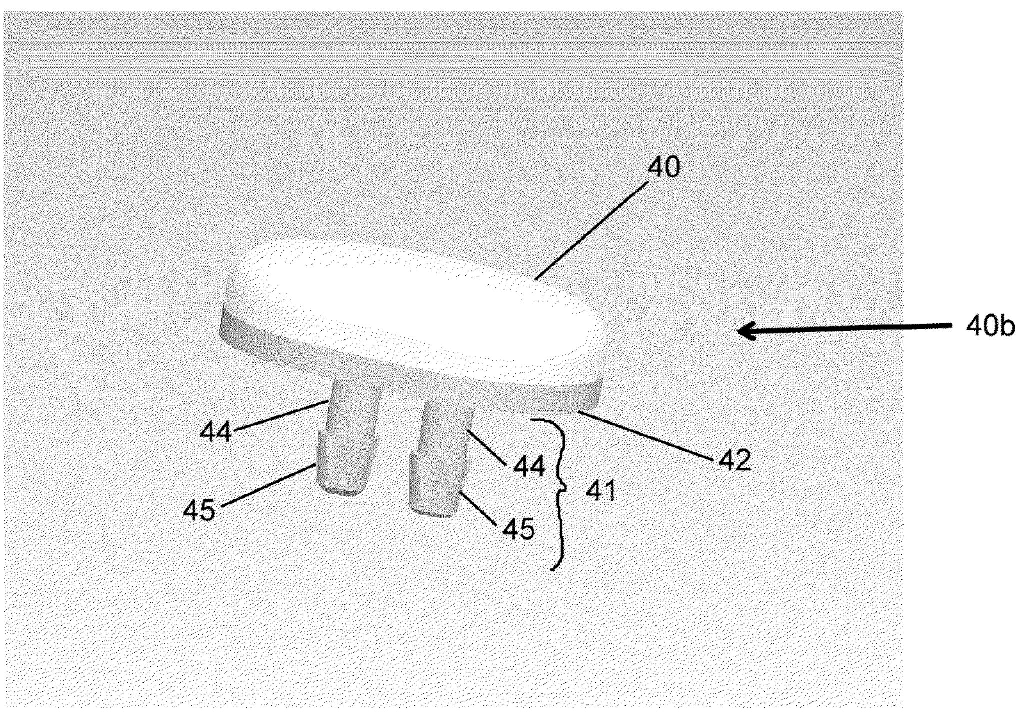

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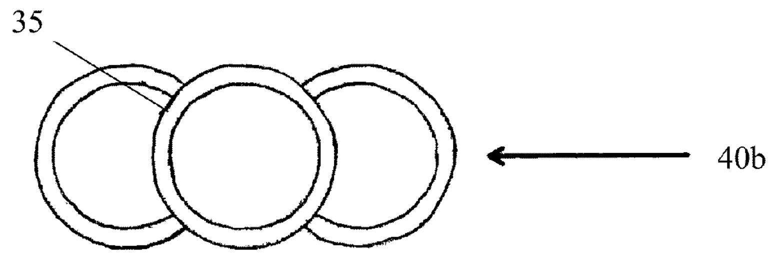

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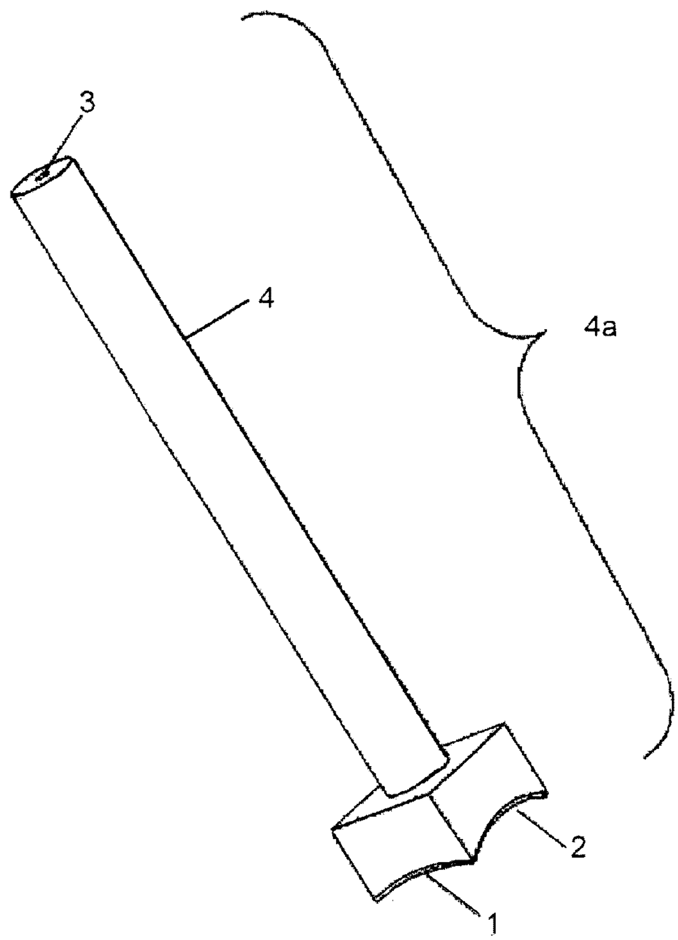

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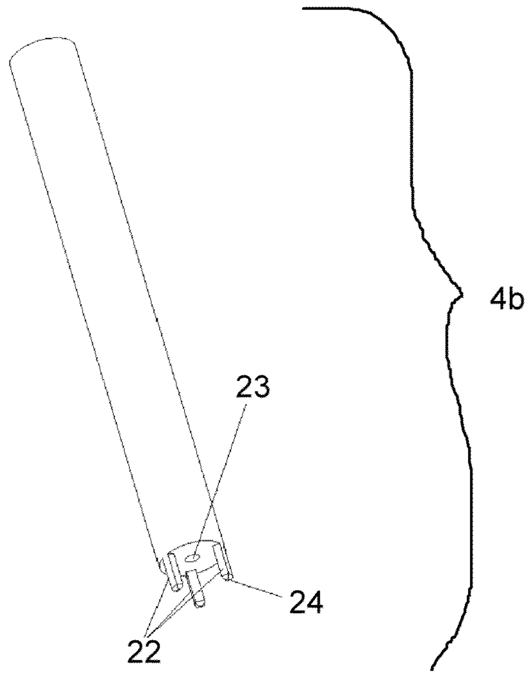

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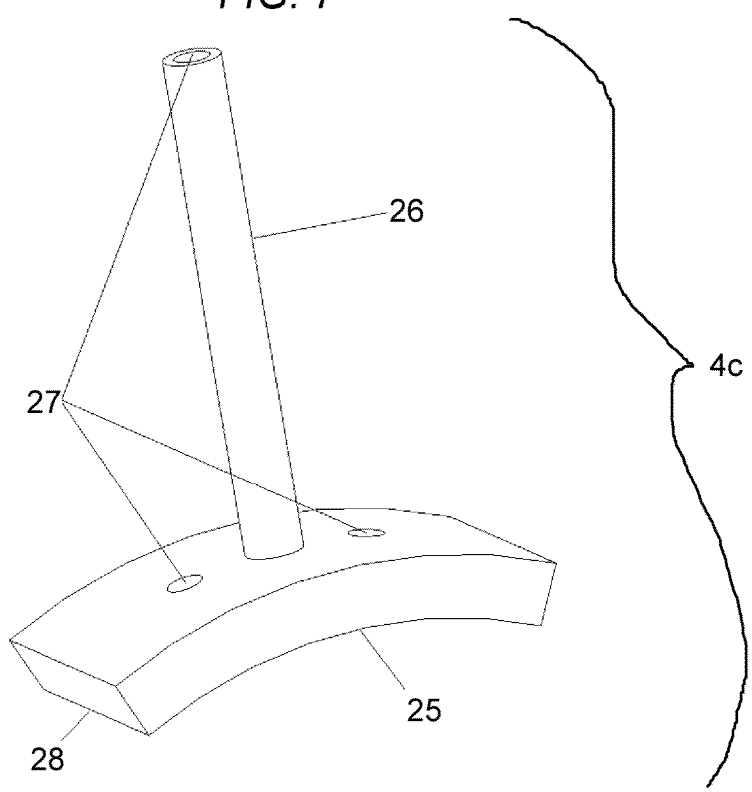

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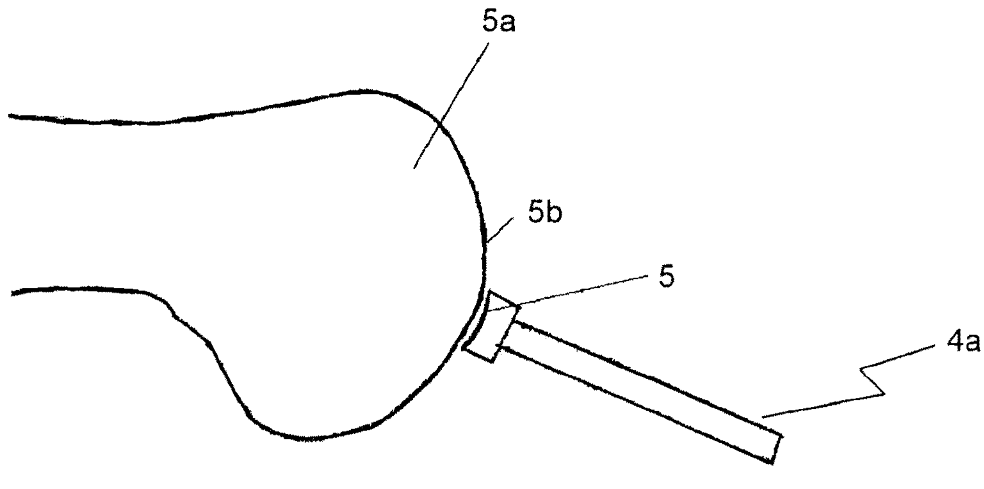

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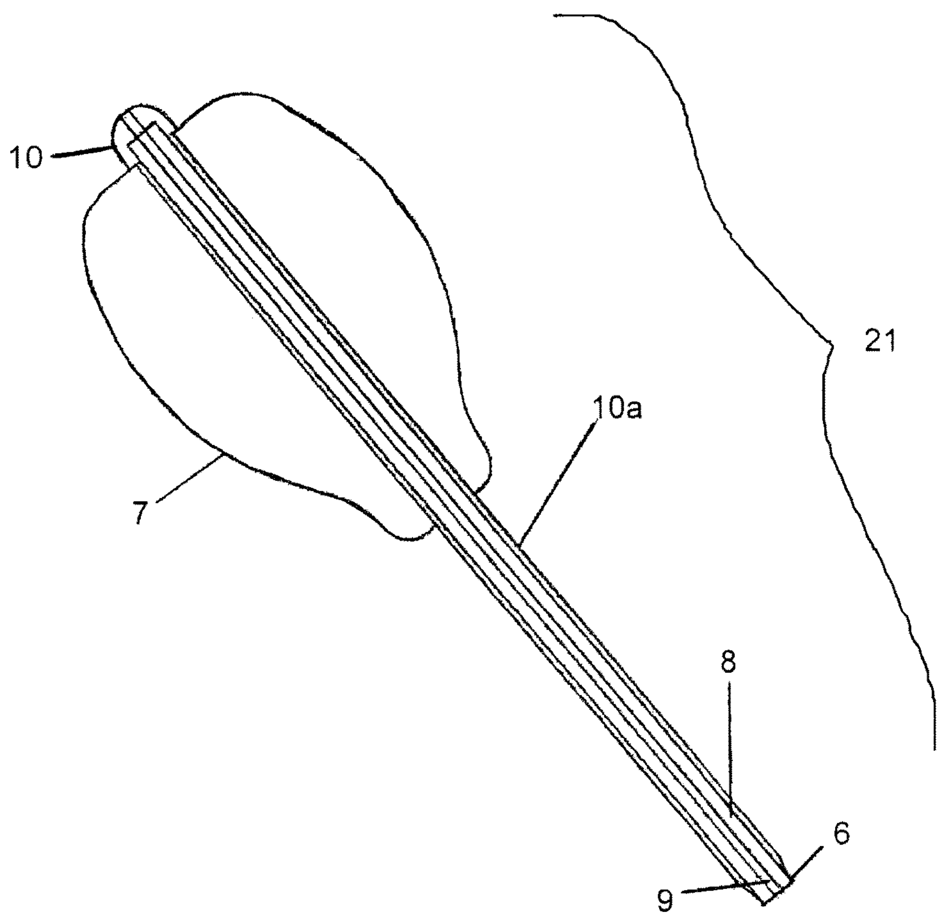

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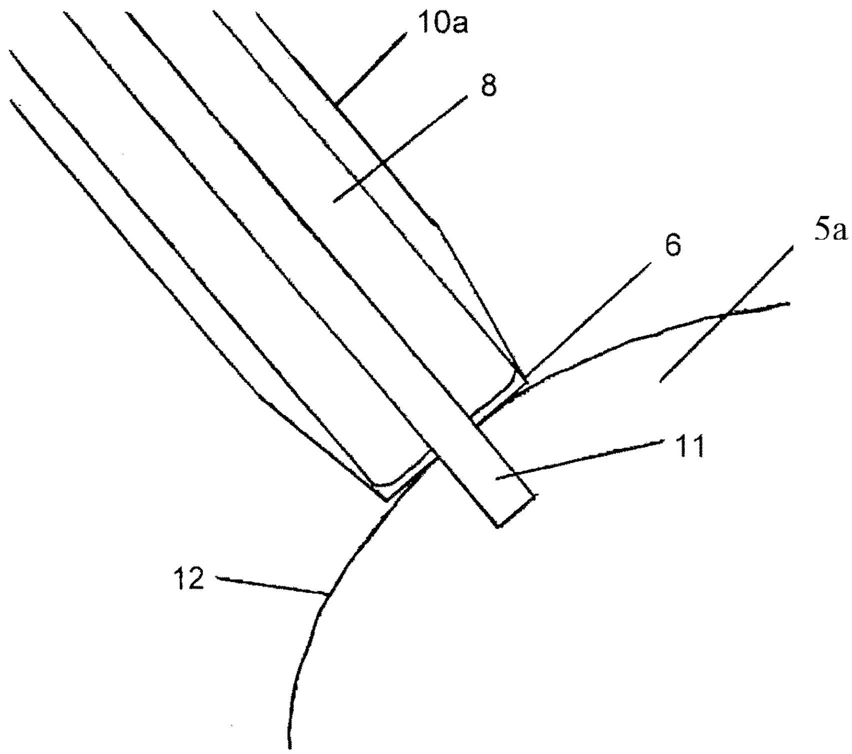

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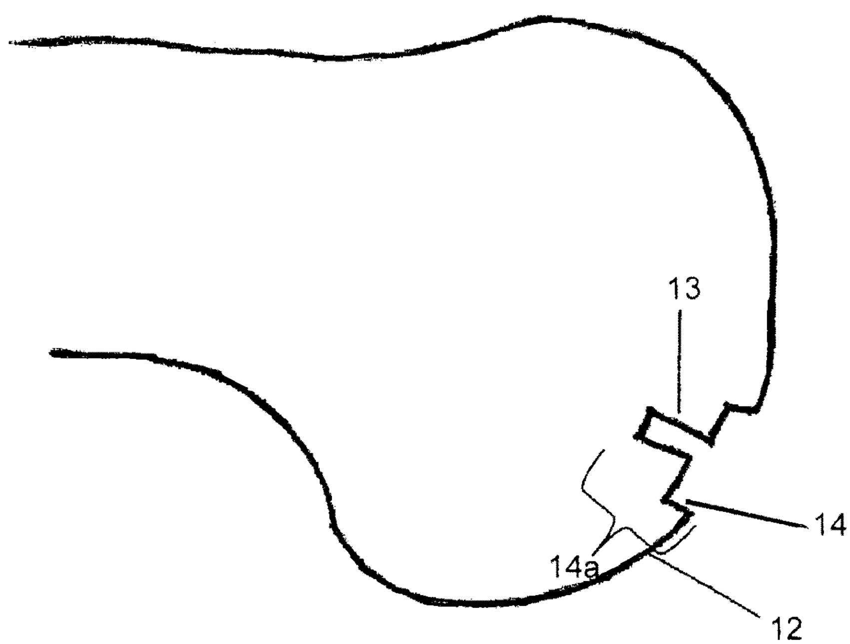

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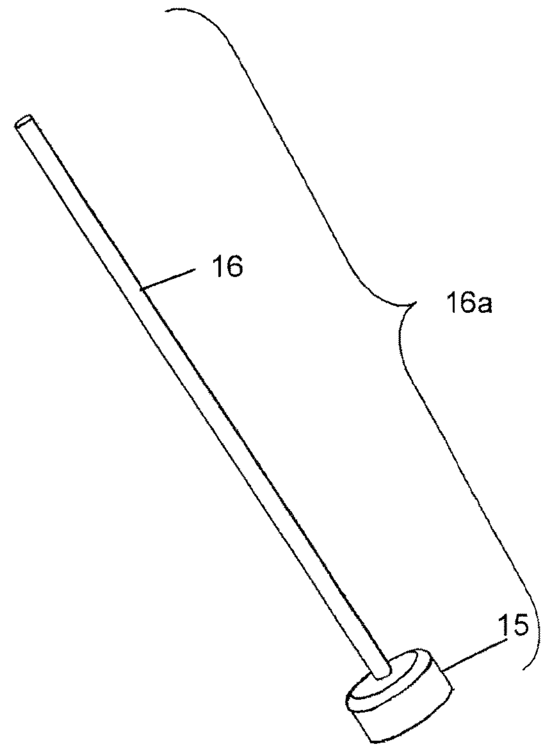

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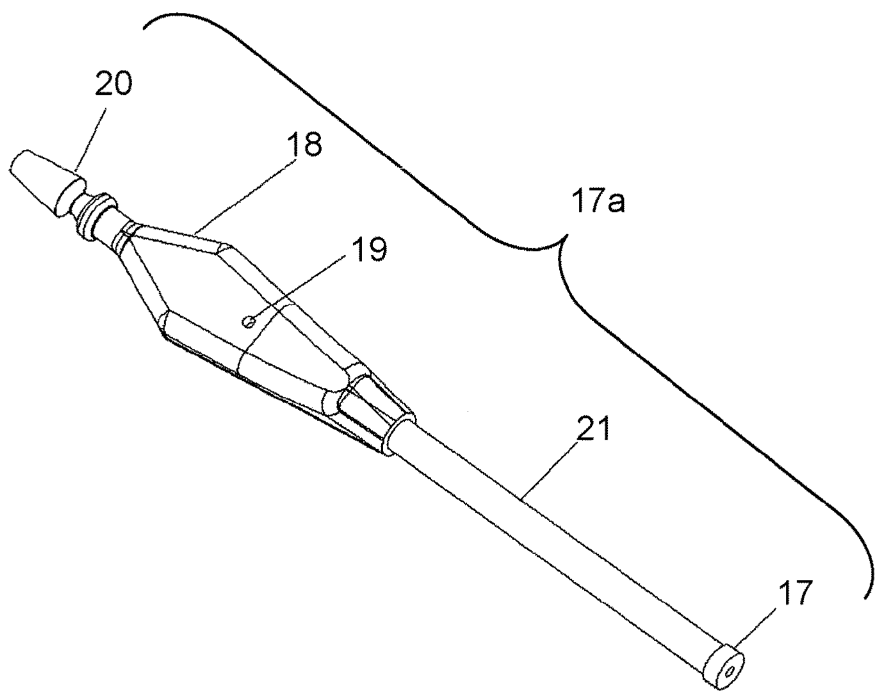

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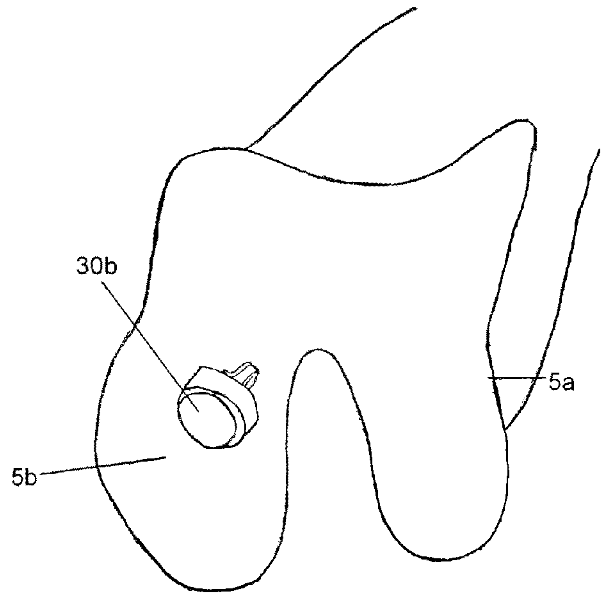

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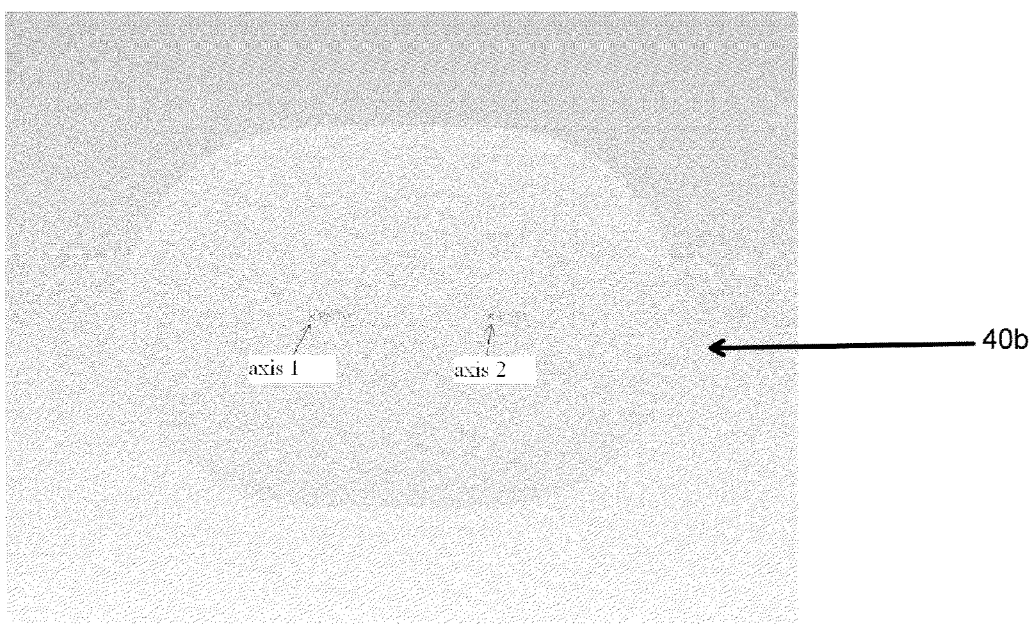

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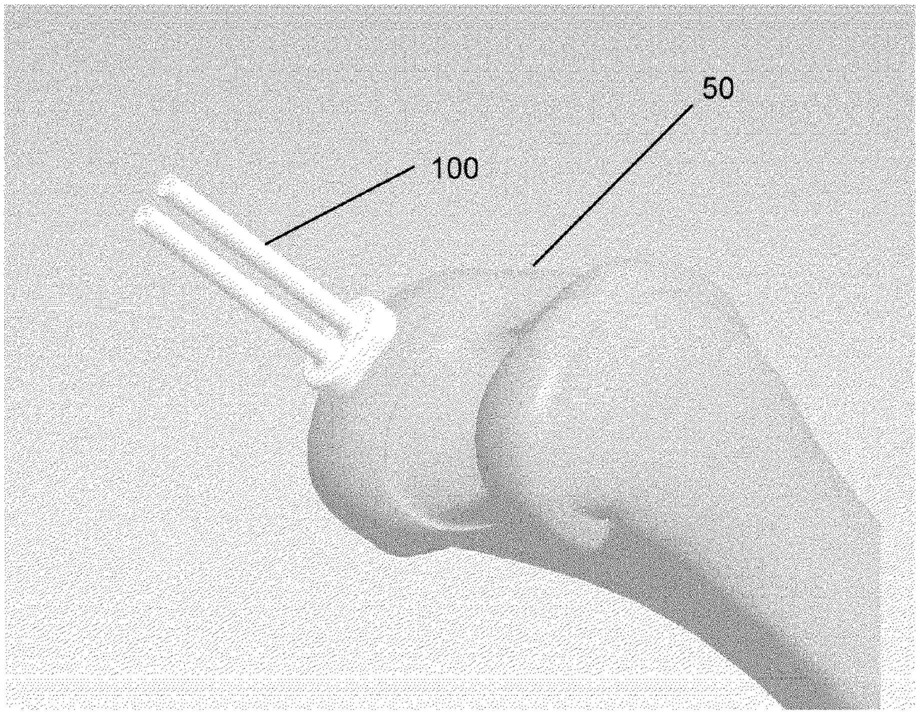

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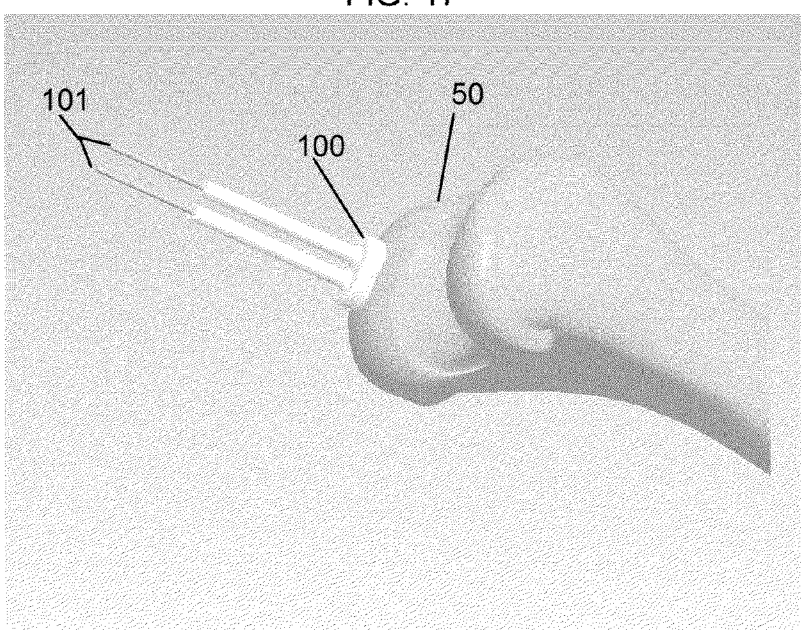

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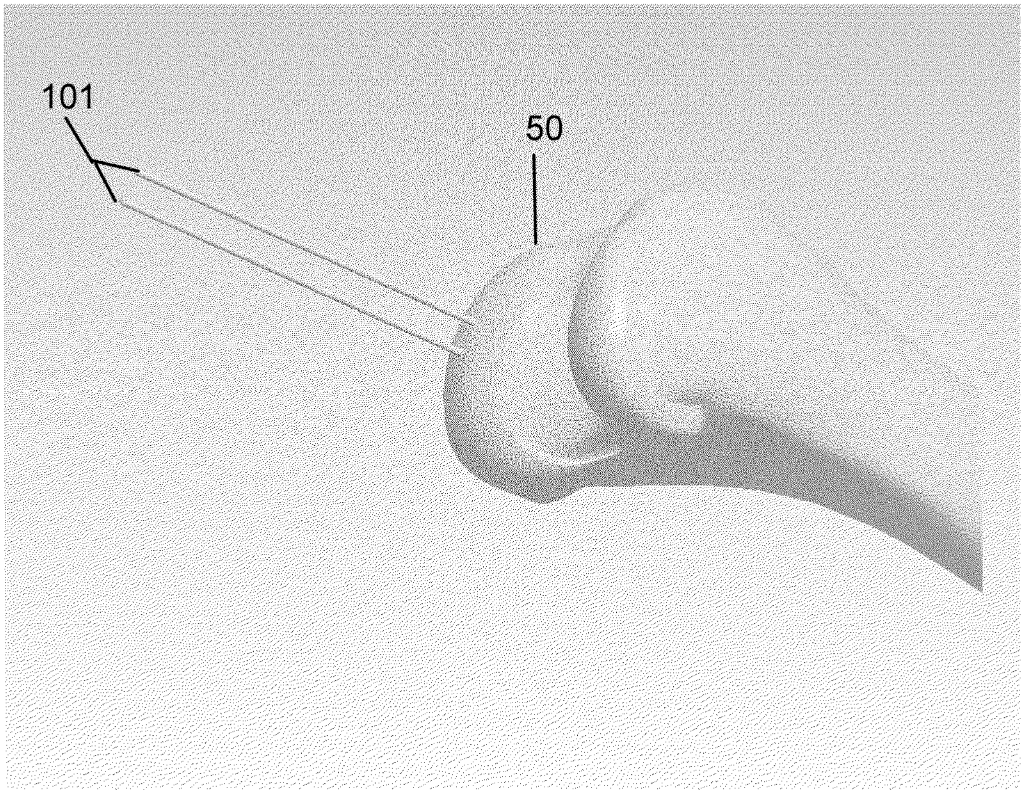

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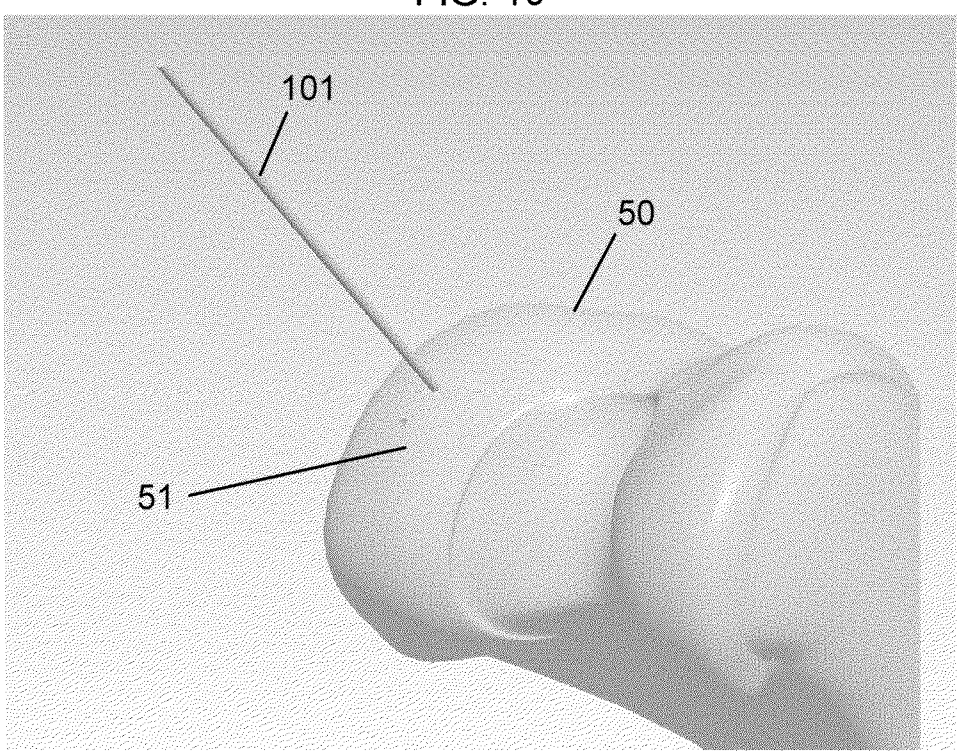

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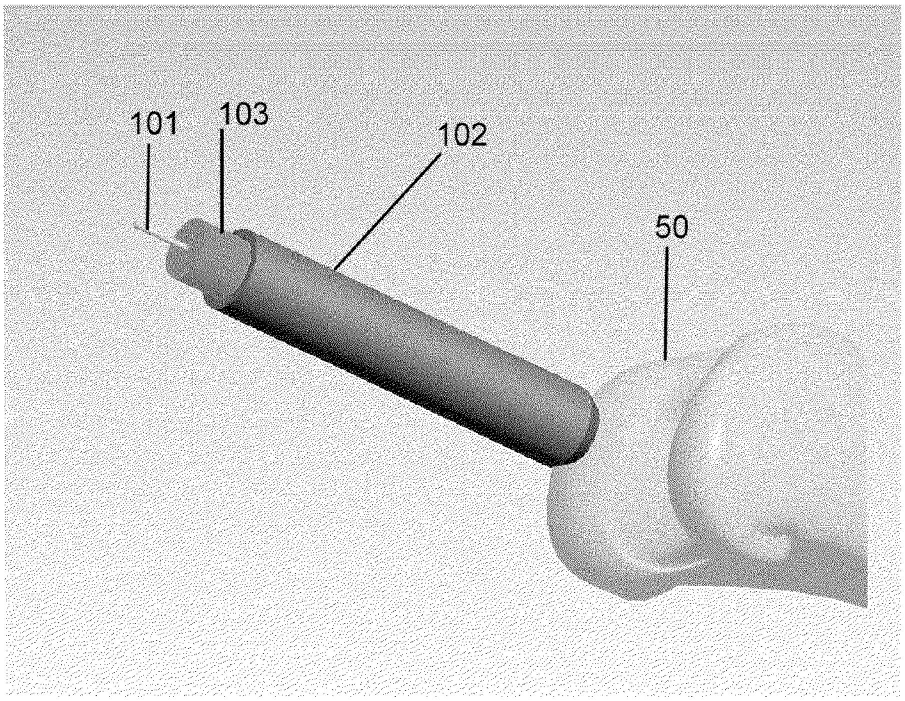

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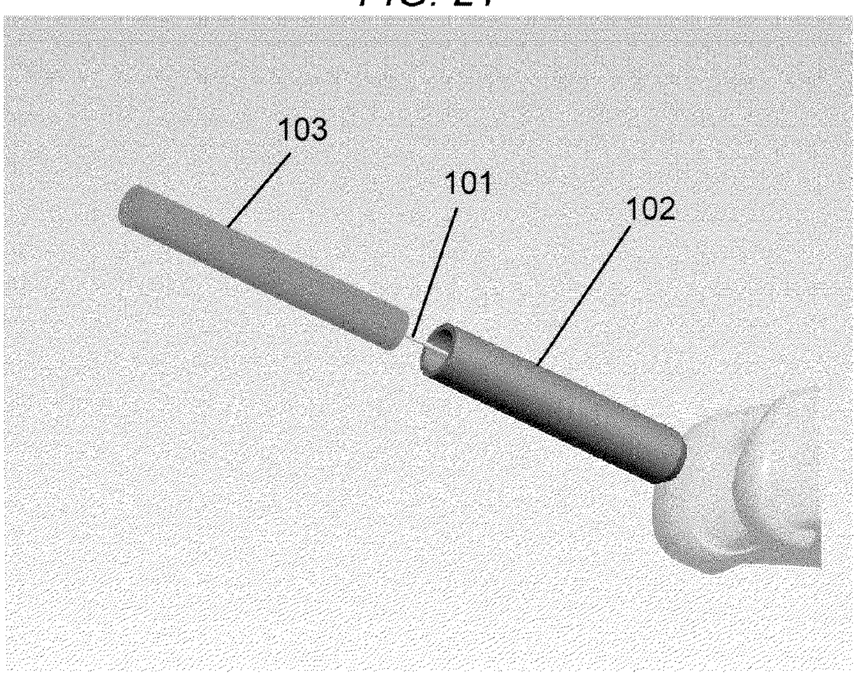

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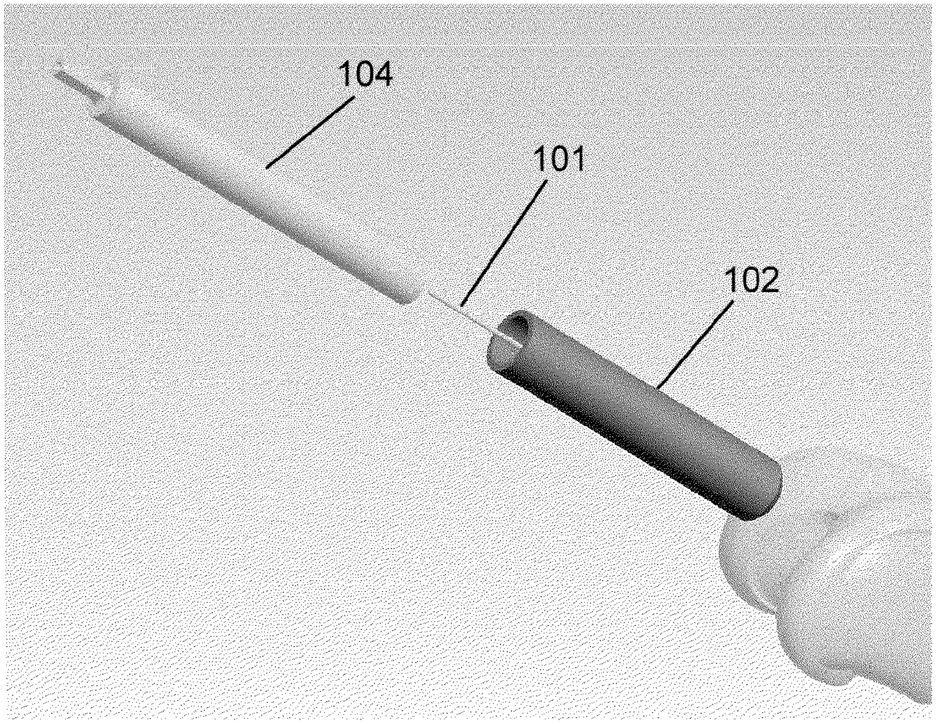

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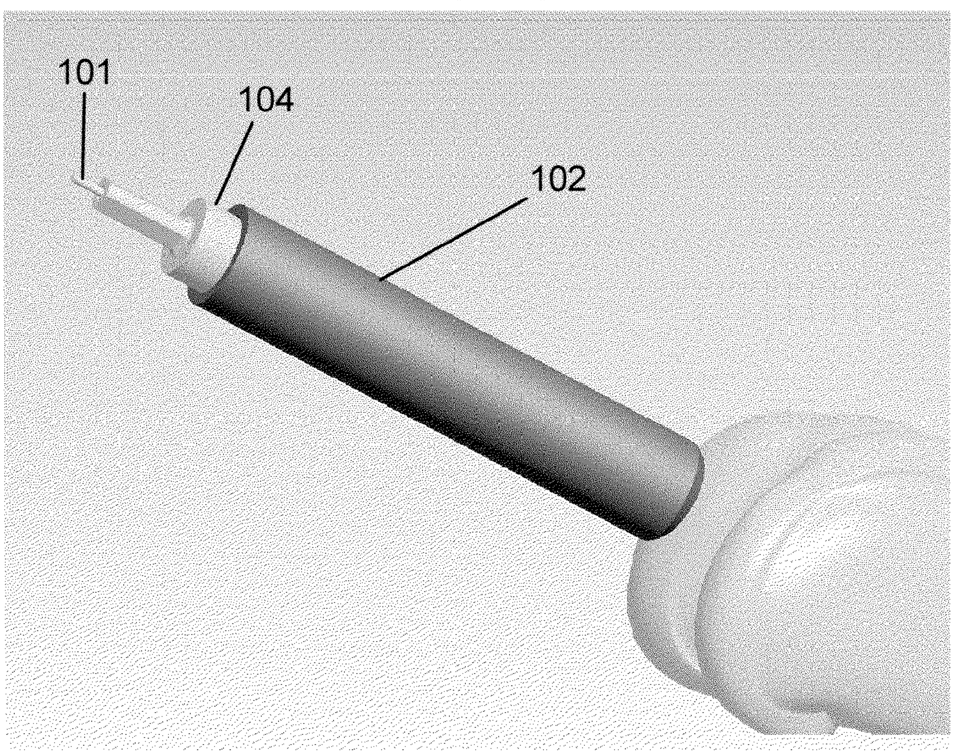

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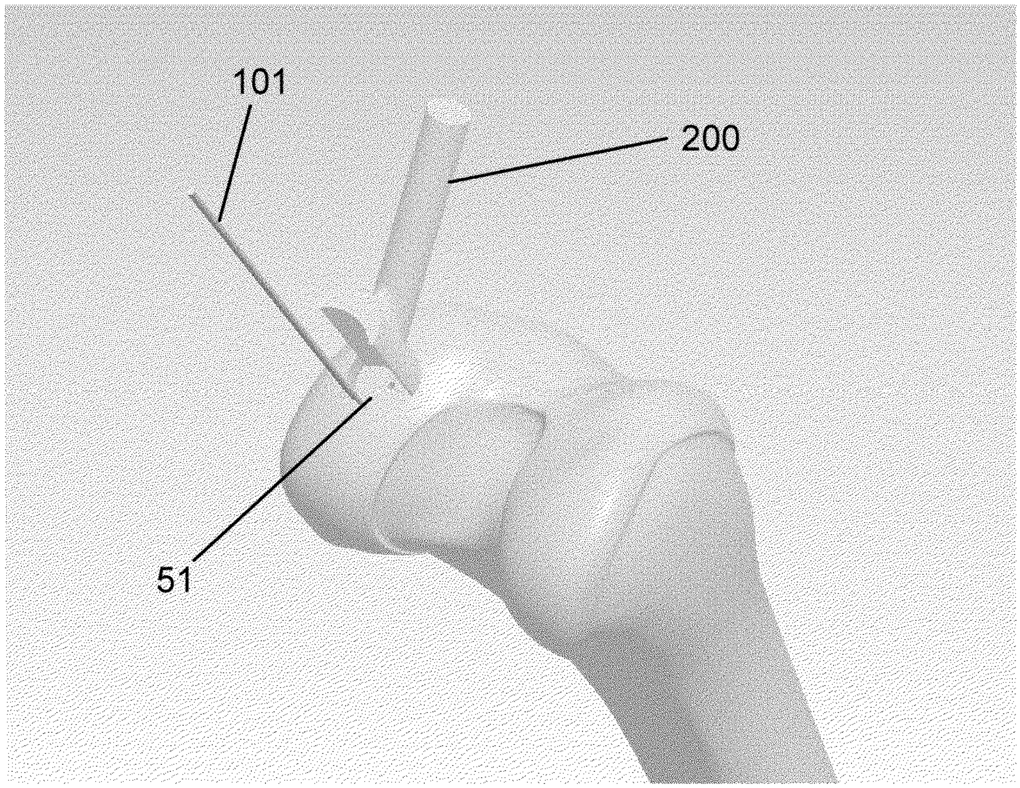

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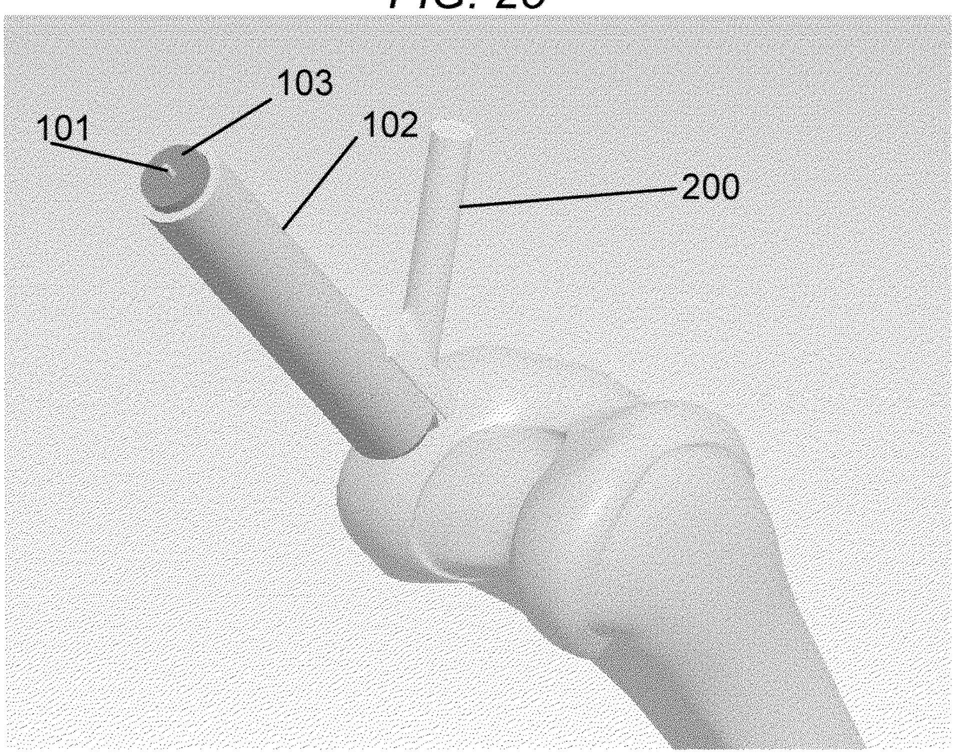

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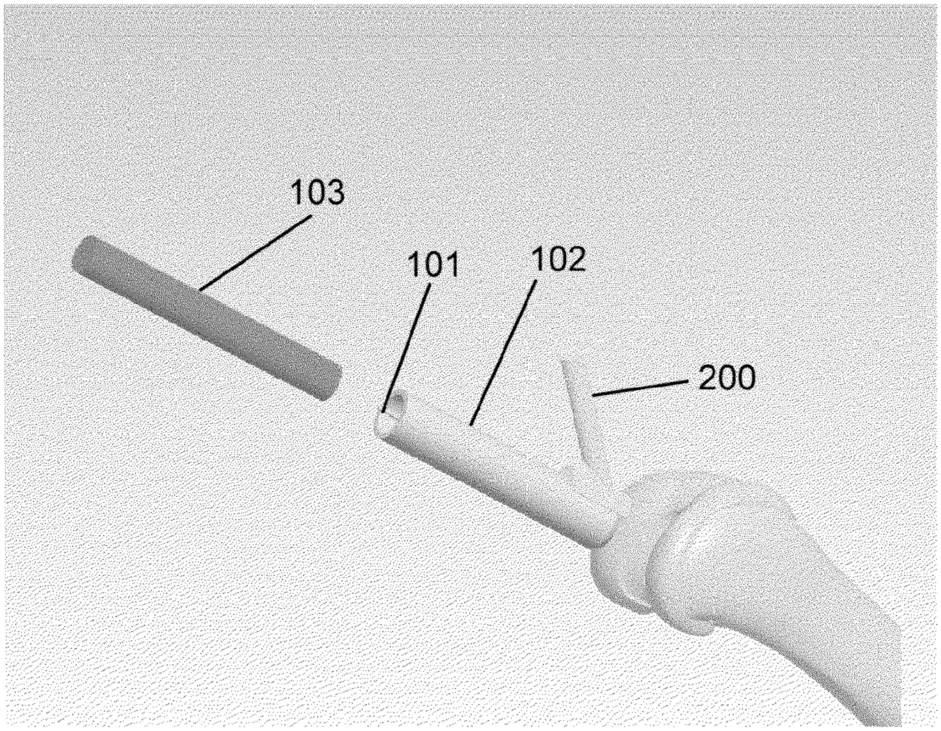

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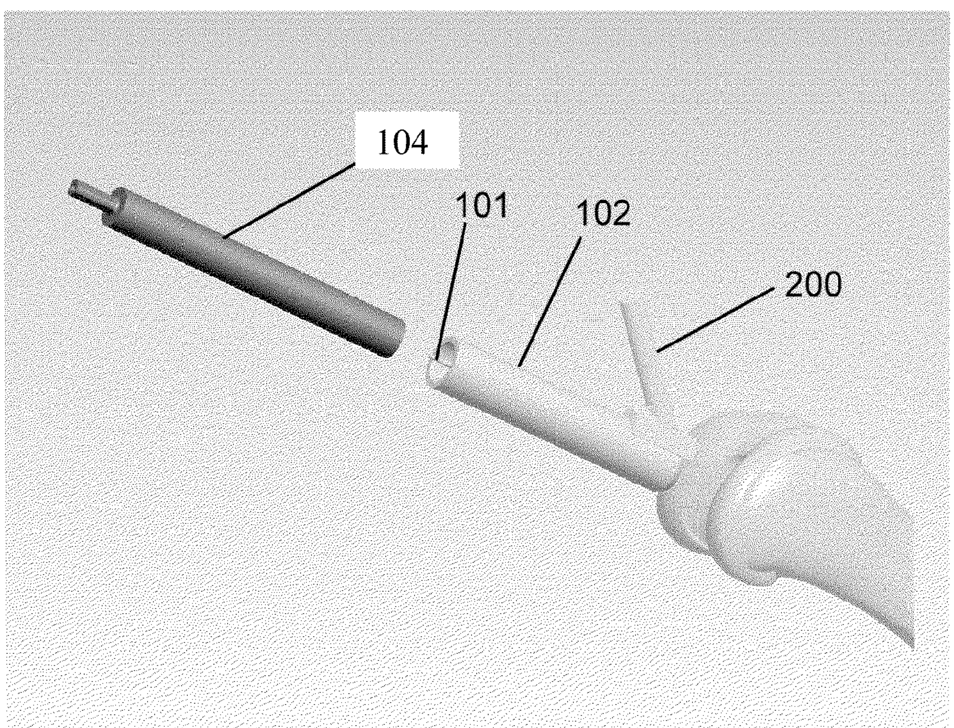

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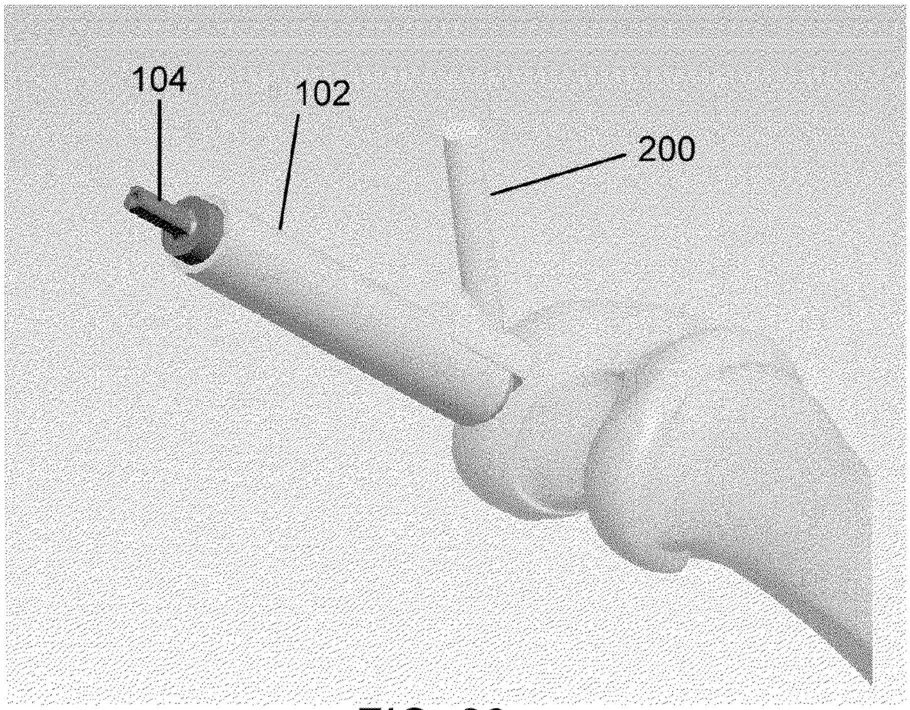

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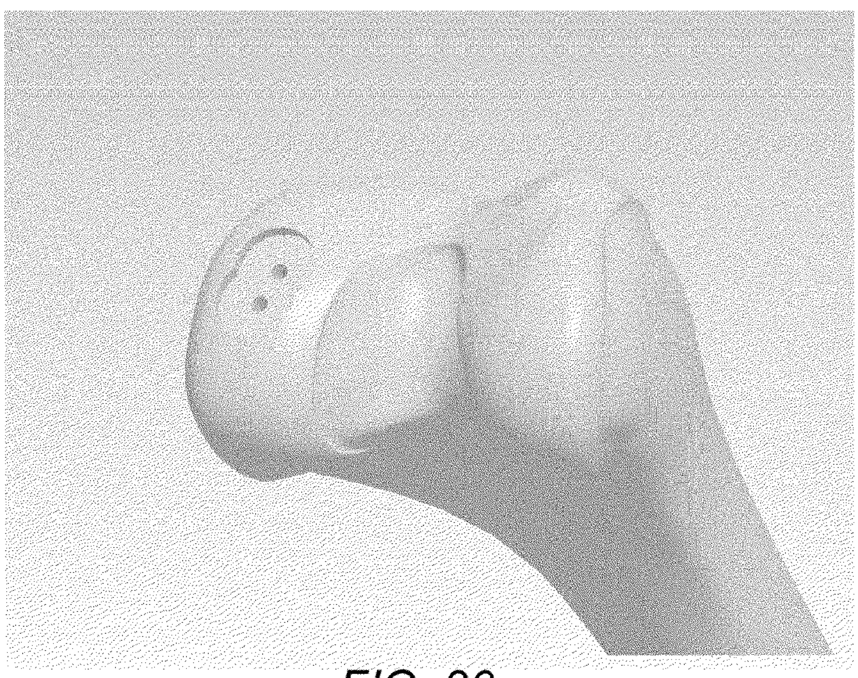
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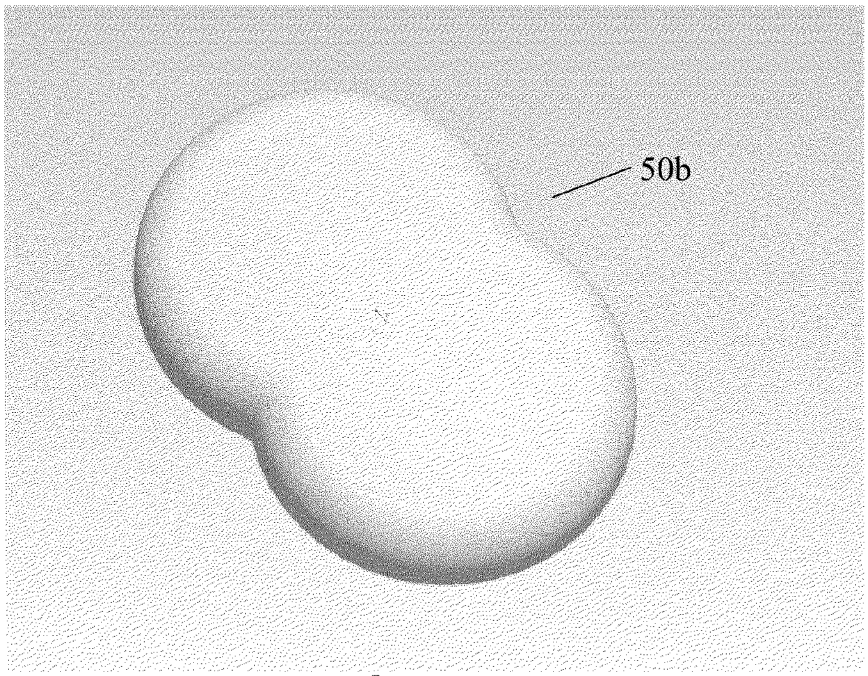

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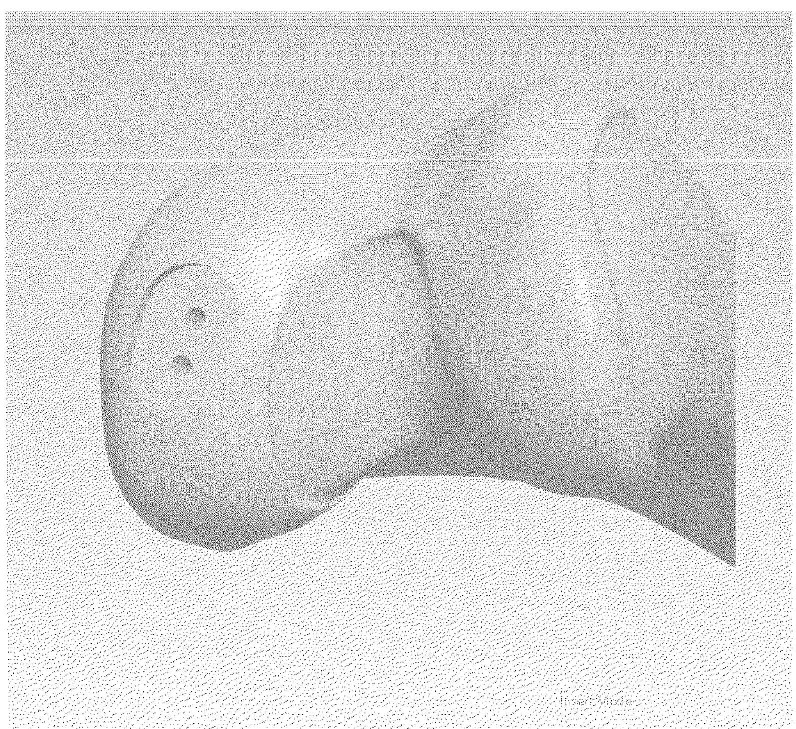

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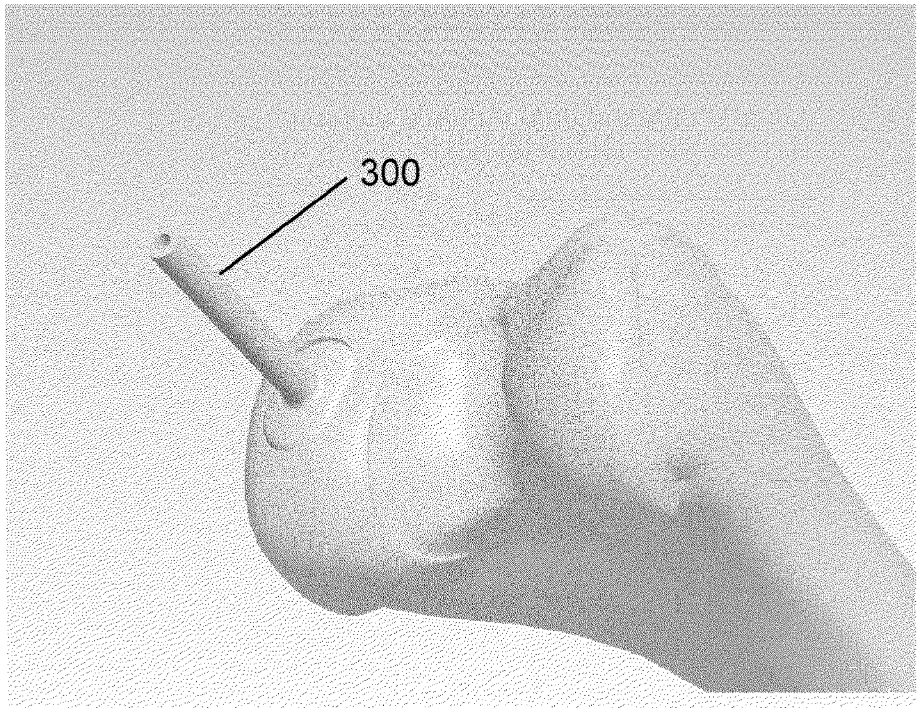

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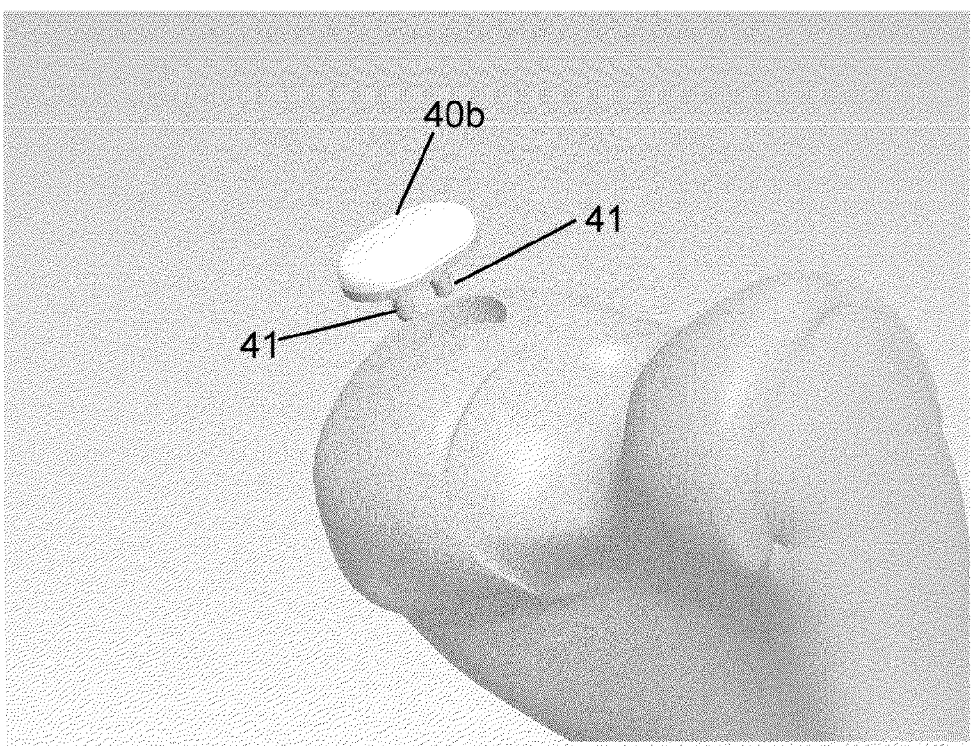

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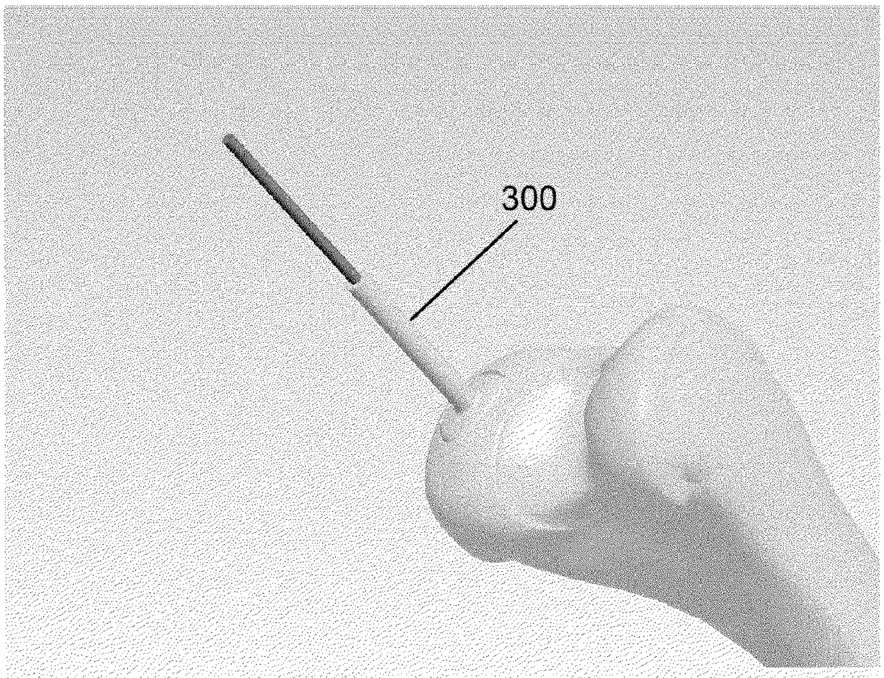

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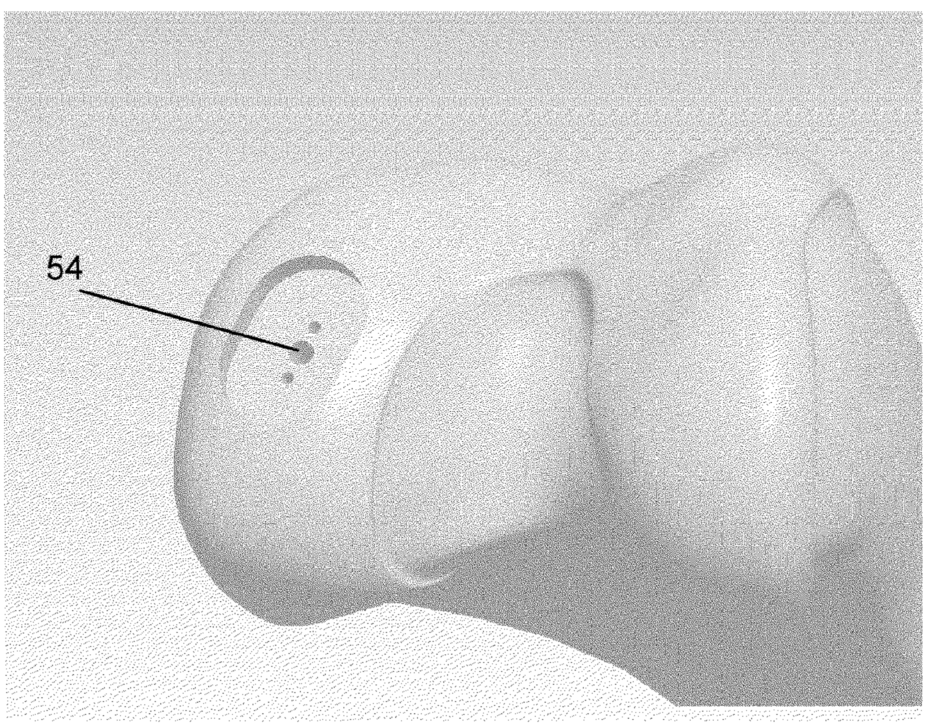

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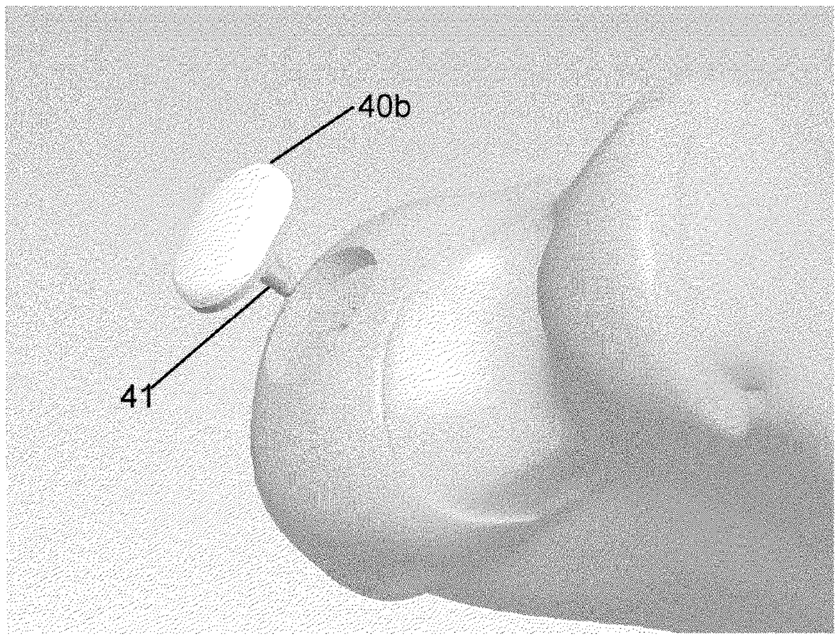

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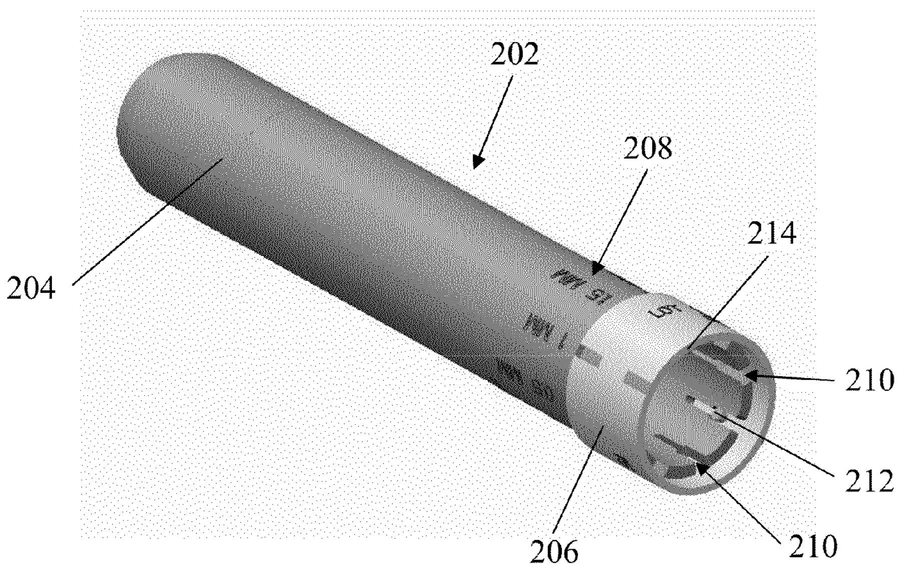

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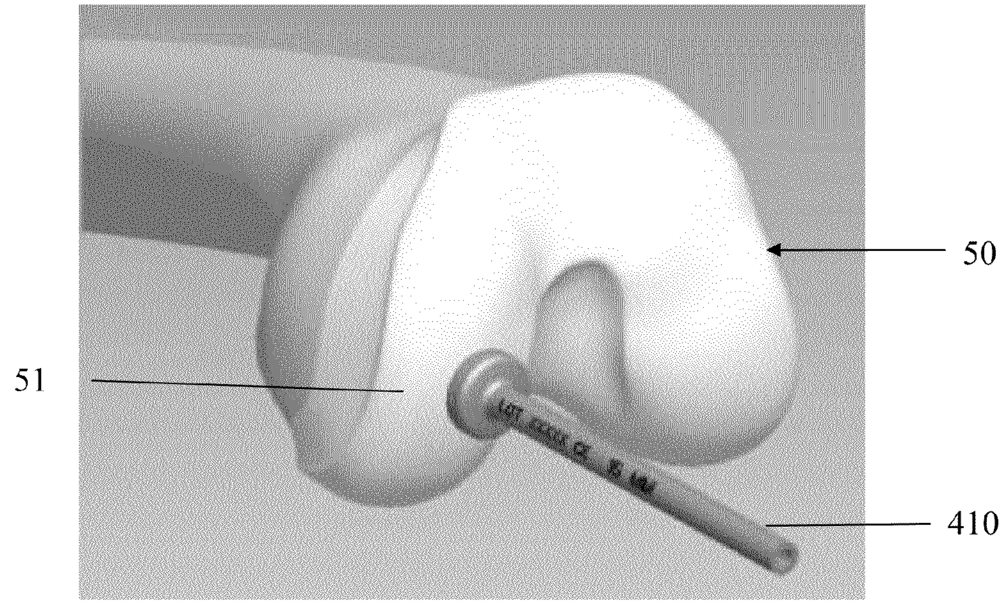

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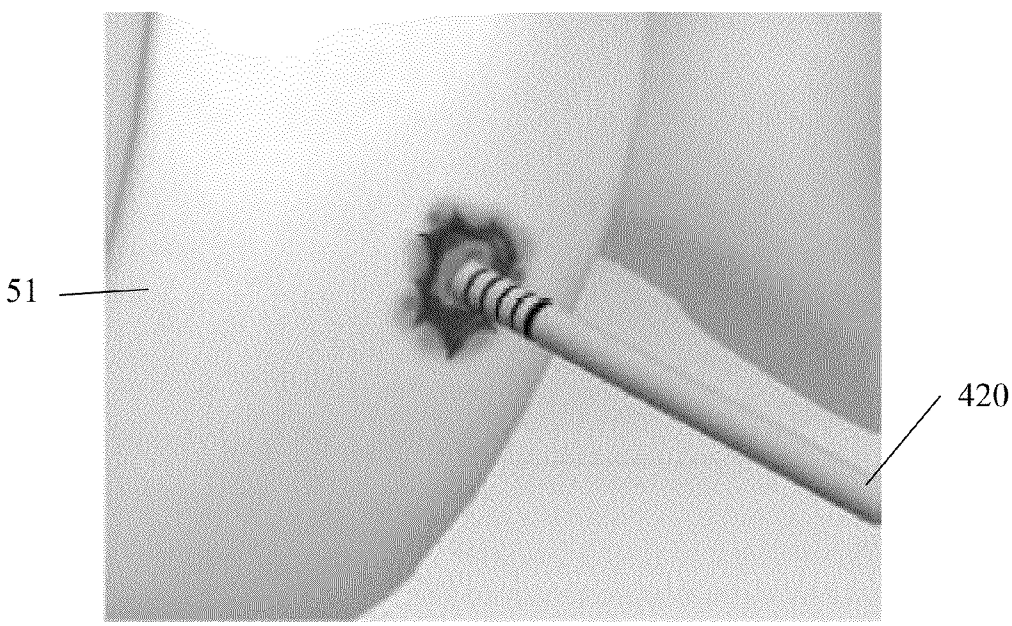

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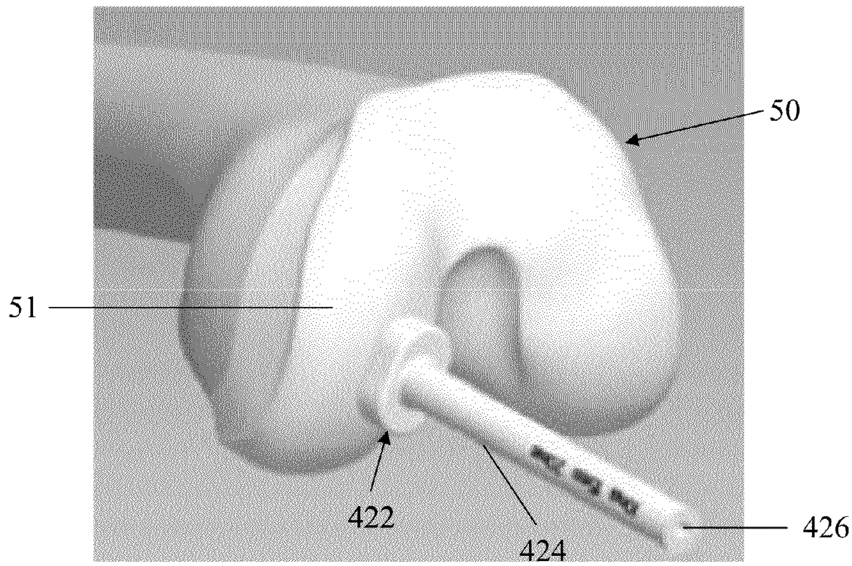

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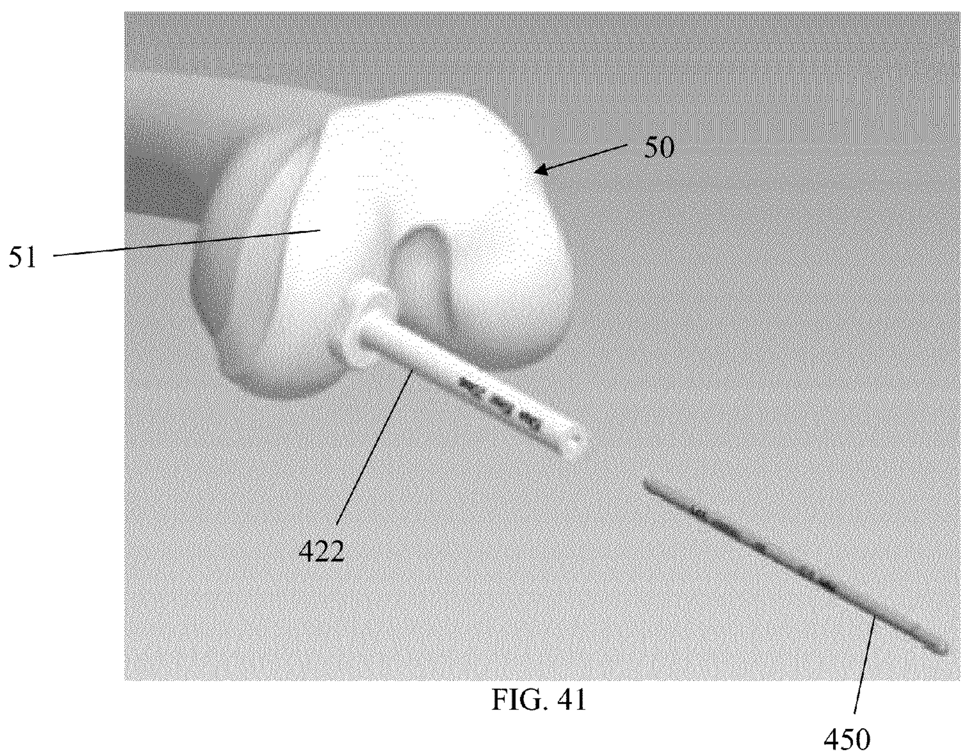

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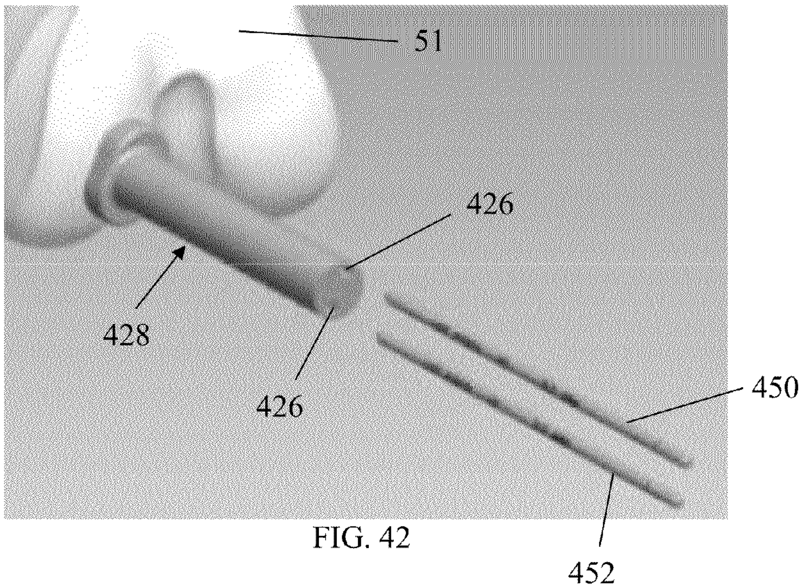

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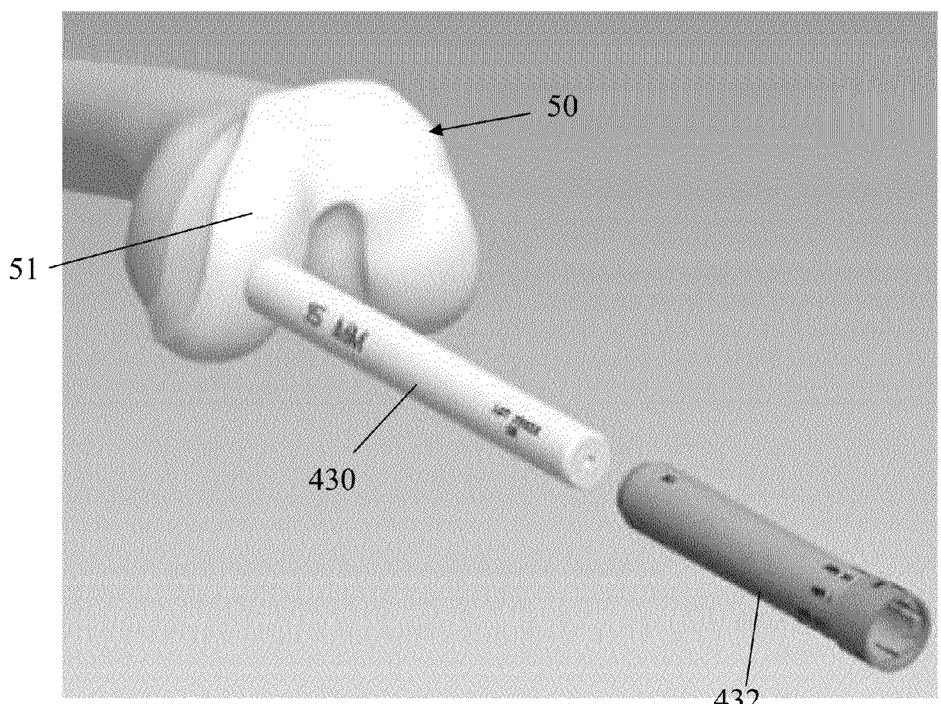

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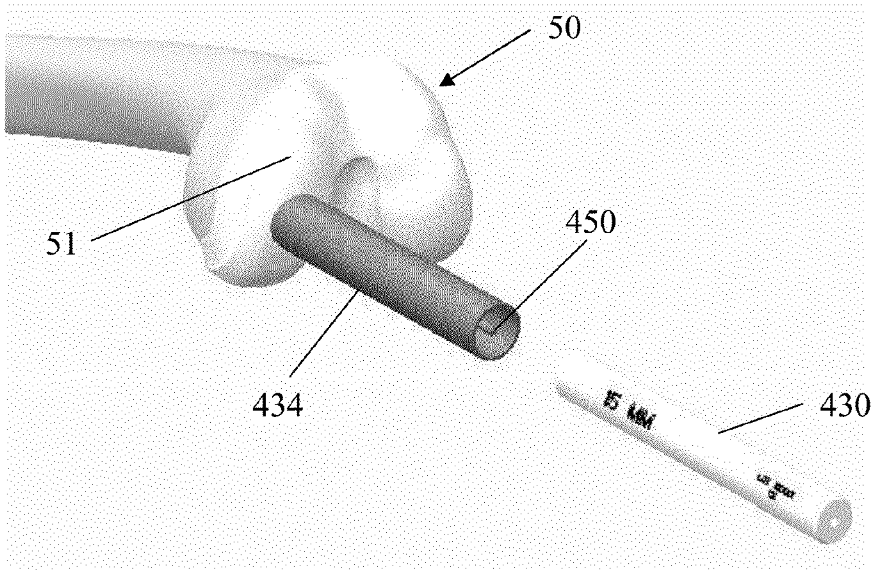

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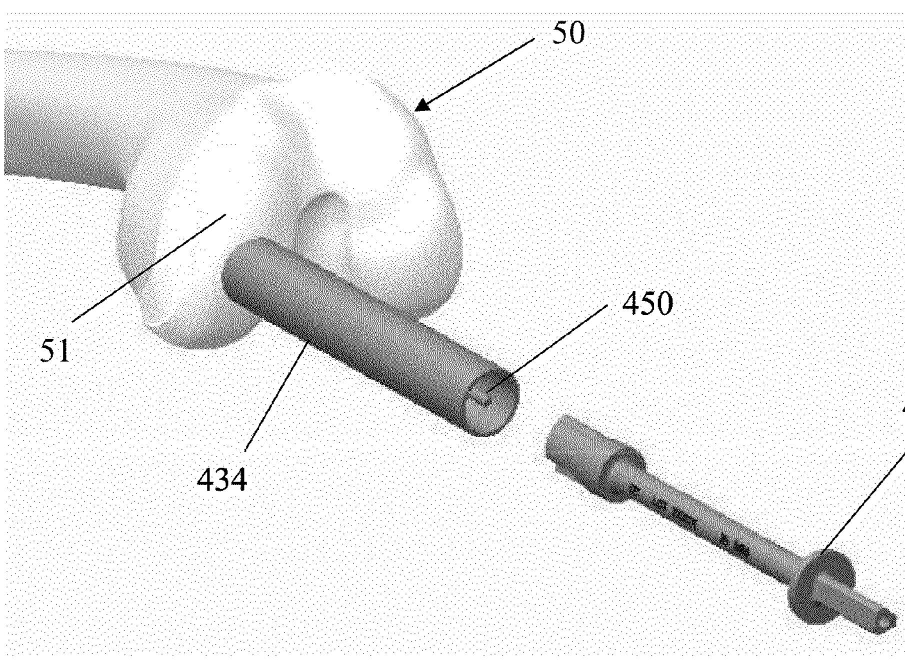
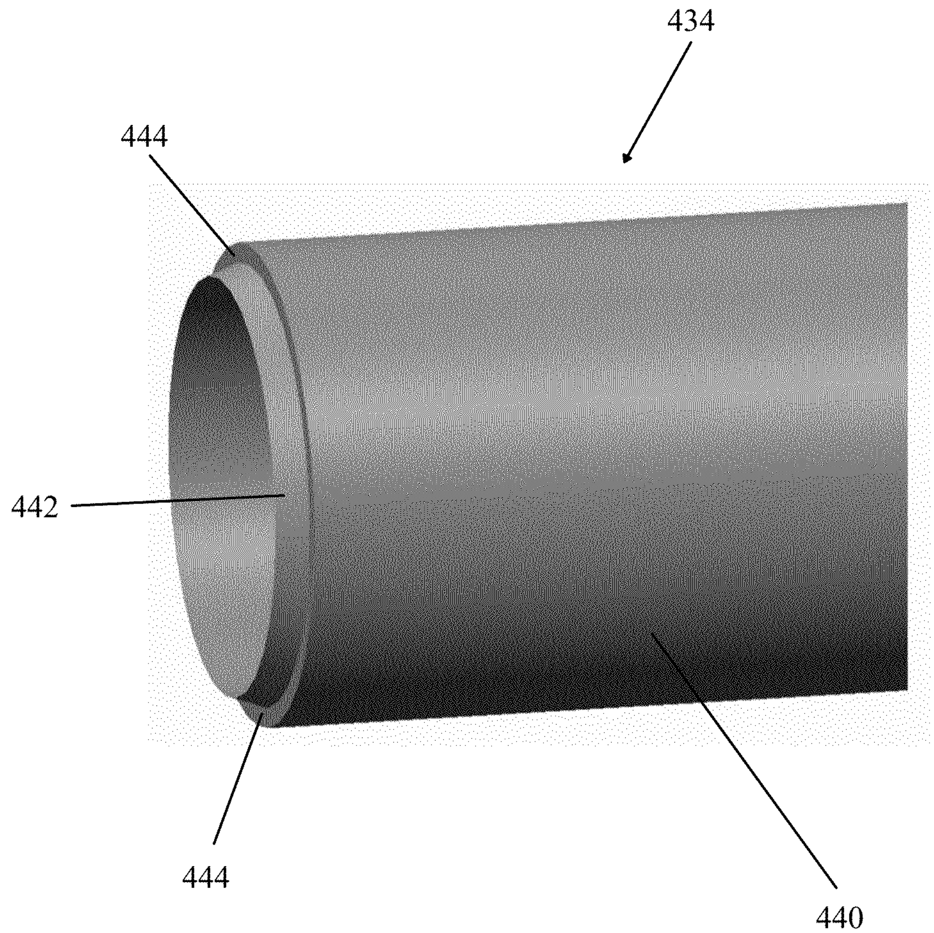


FIG. 45A



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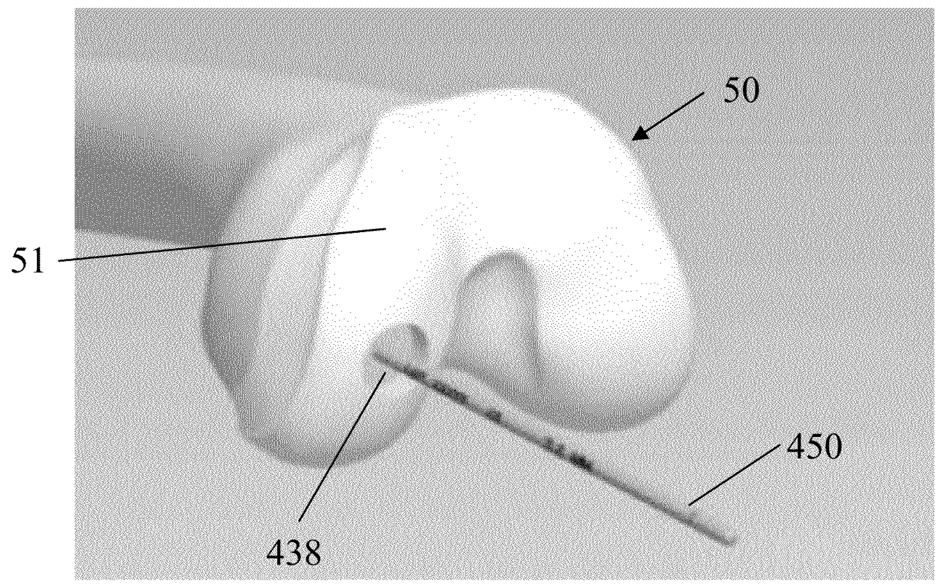

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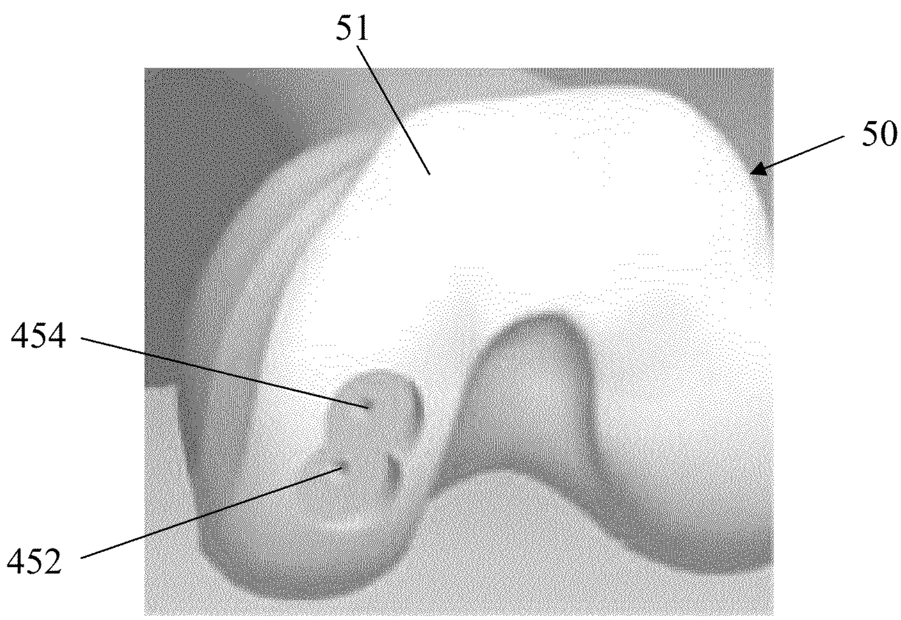

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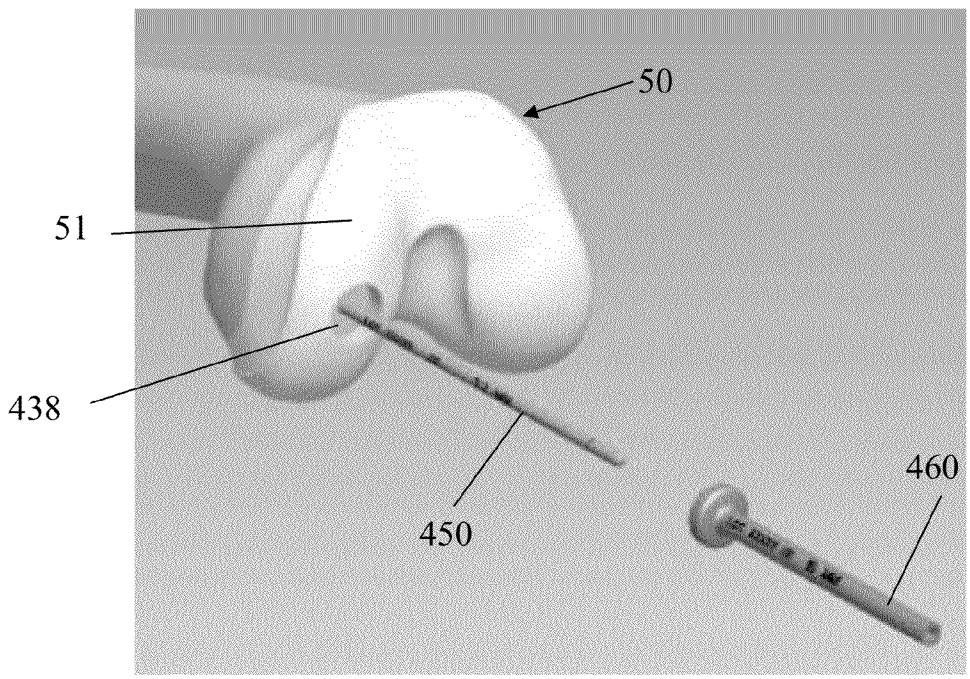

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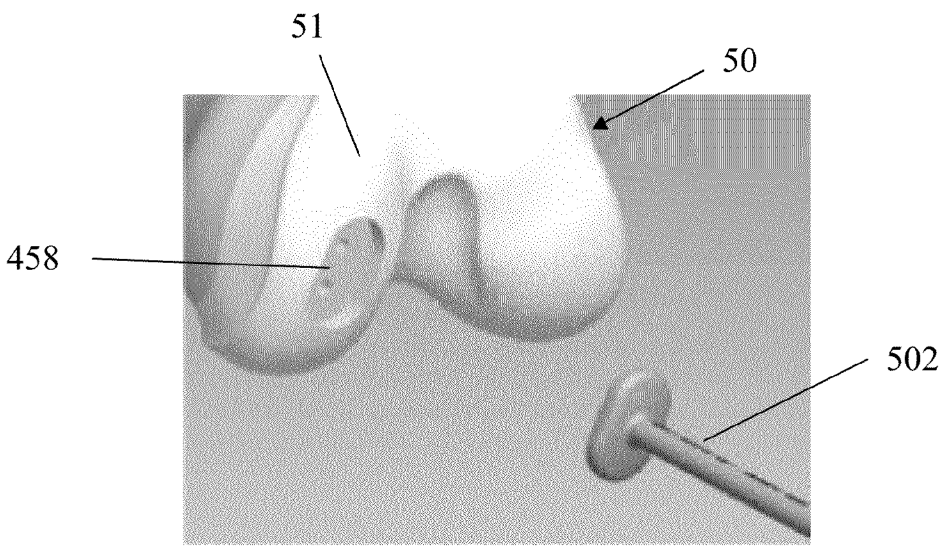


FIG. 49

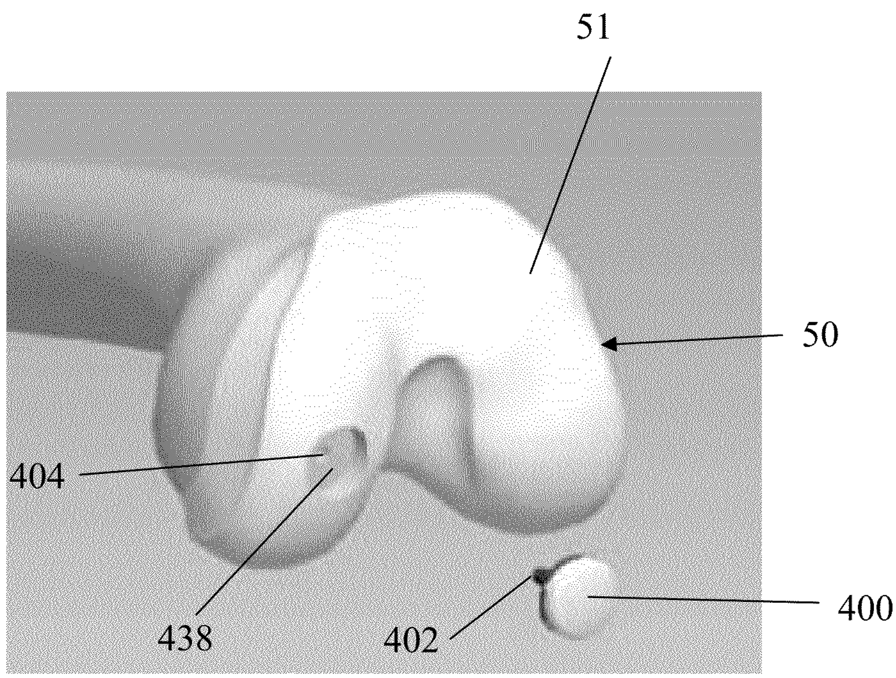


FIG. 50

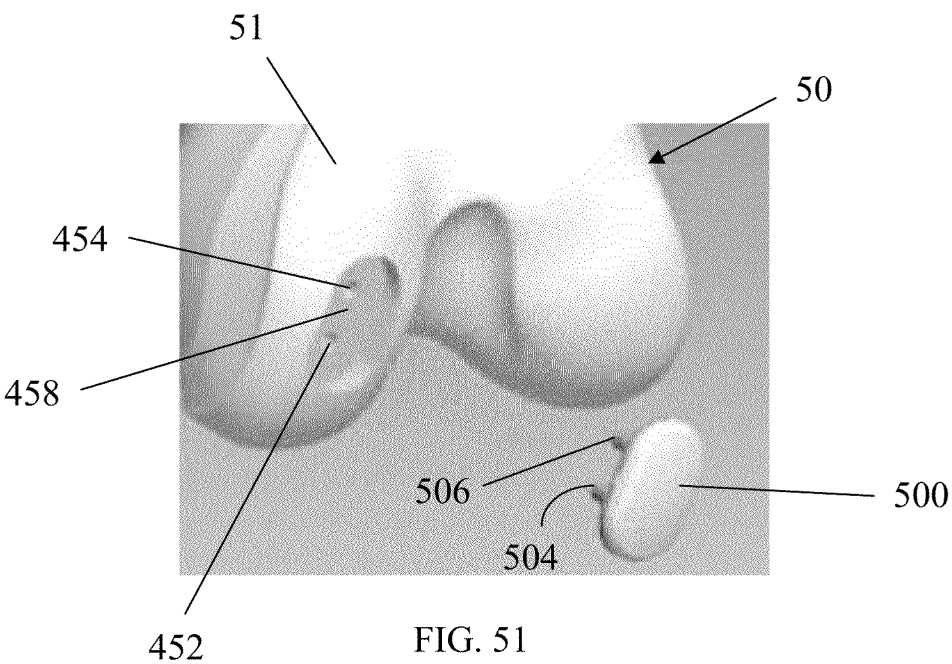
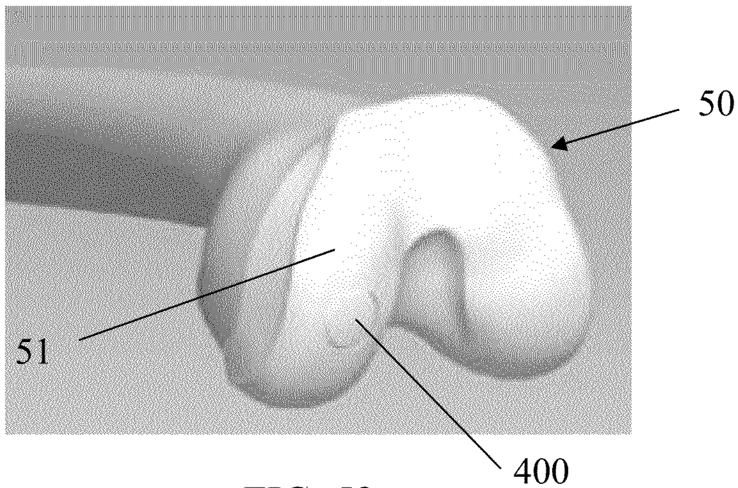


FIG. 51



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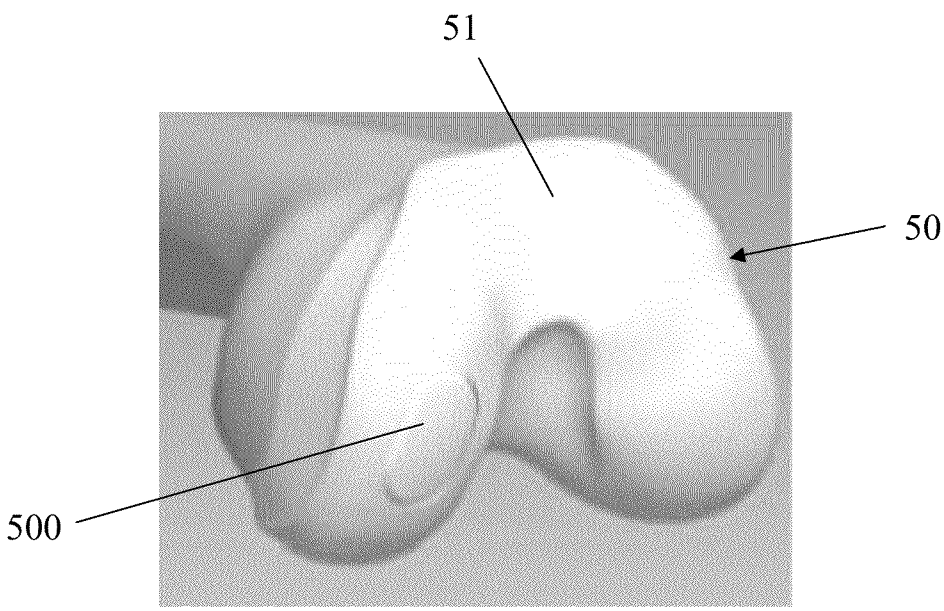

FIG. 53

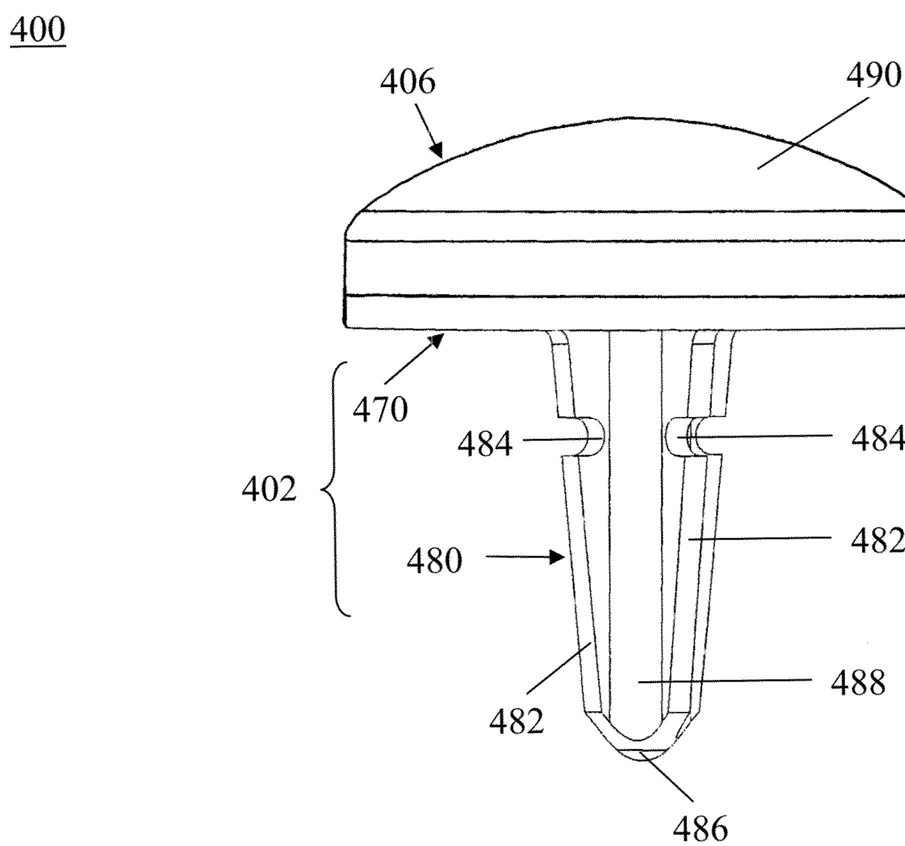

FIG. 54

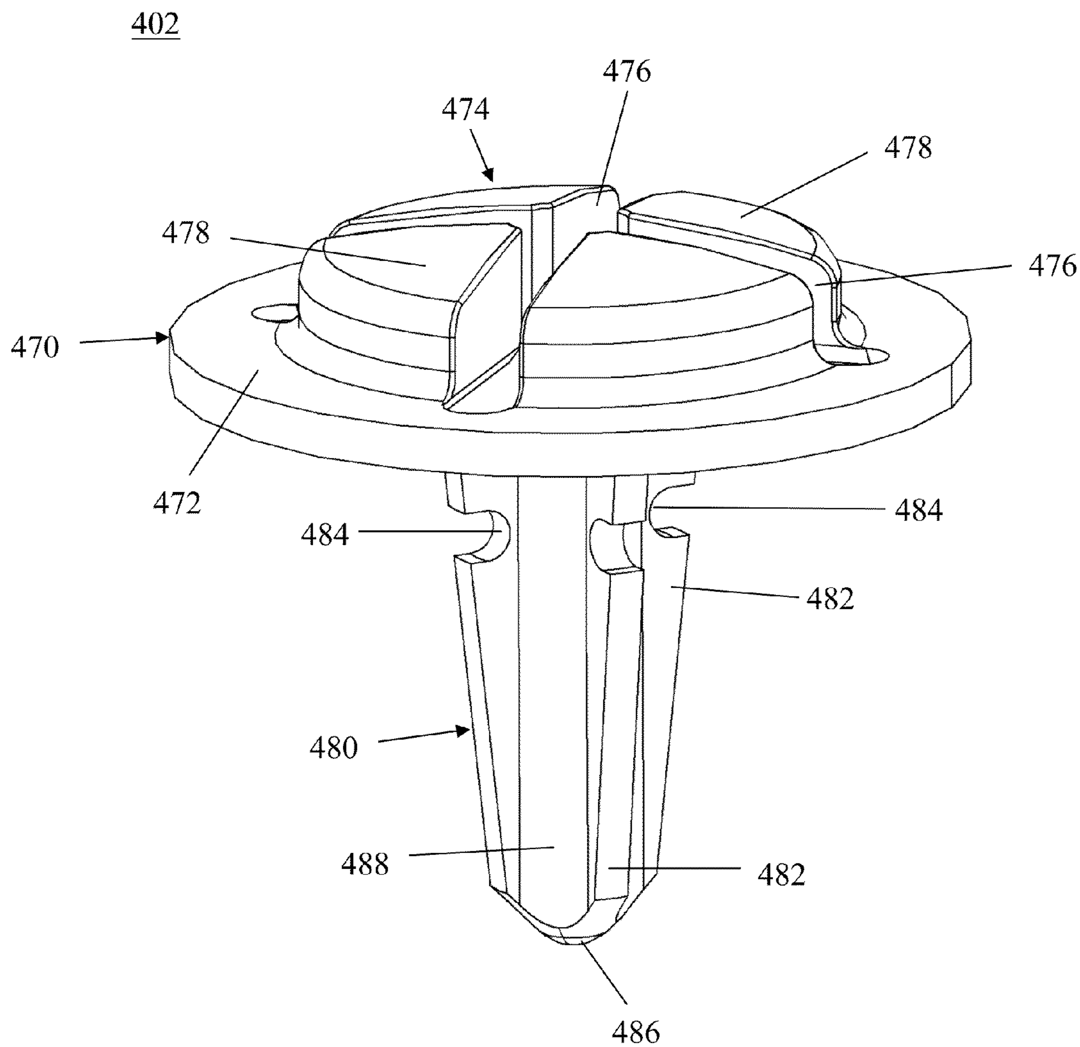

FIG. 55

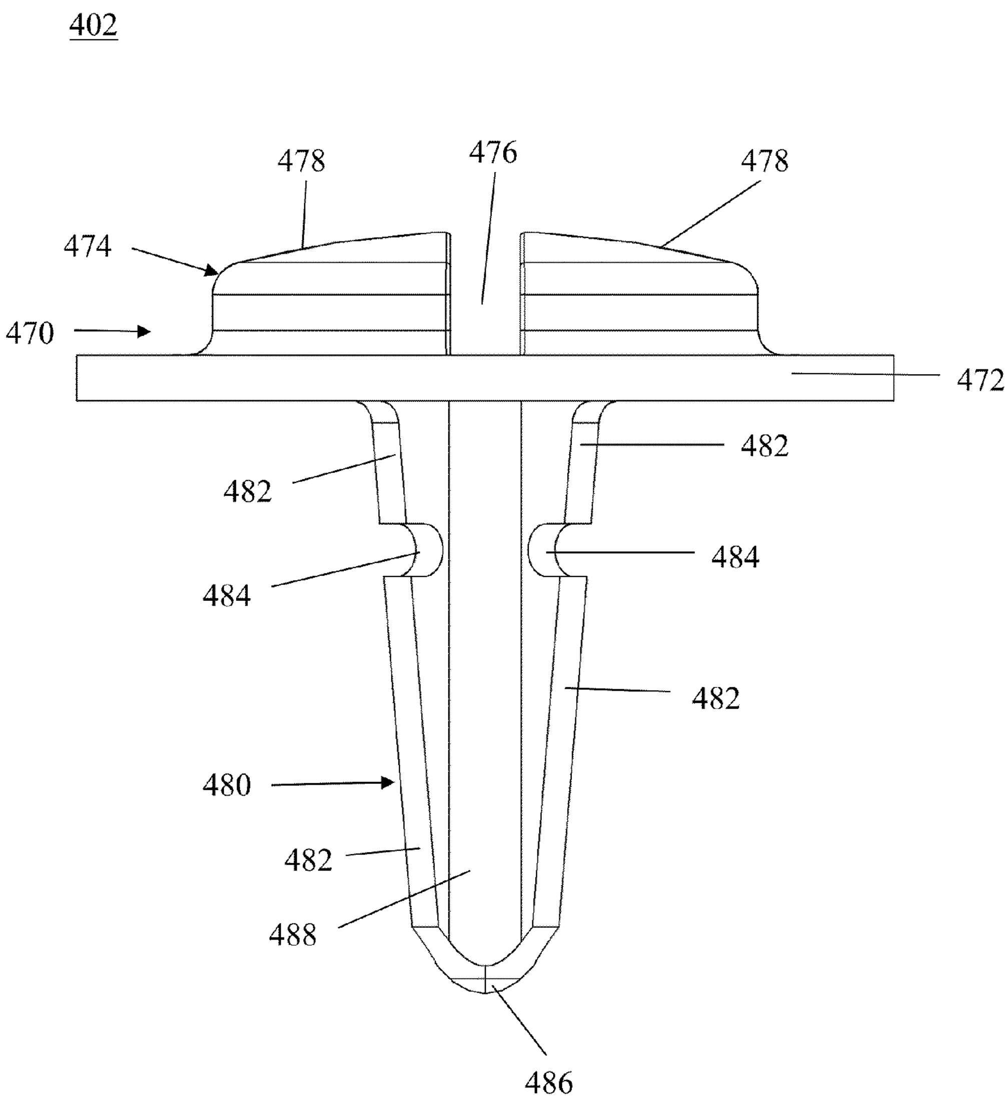

FIG. 56

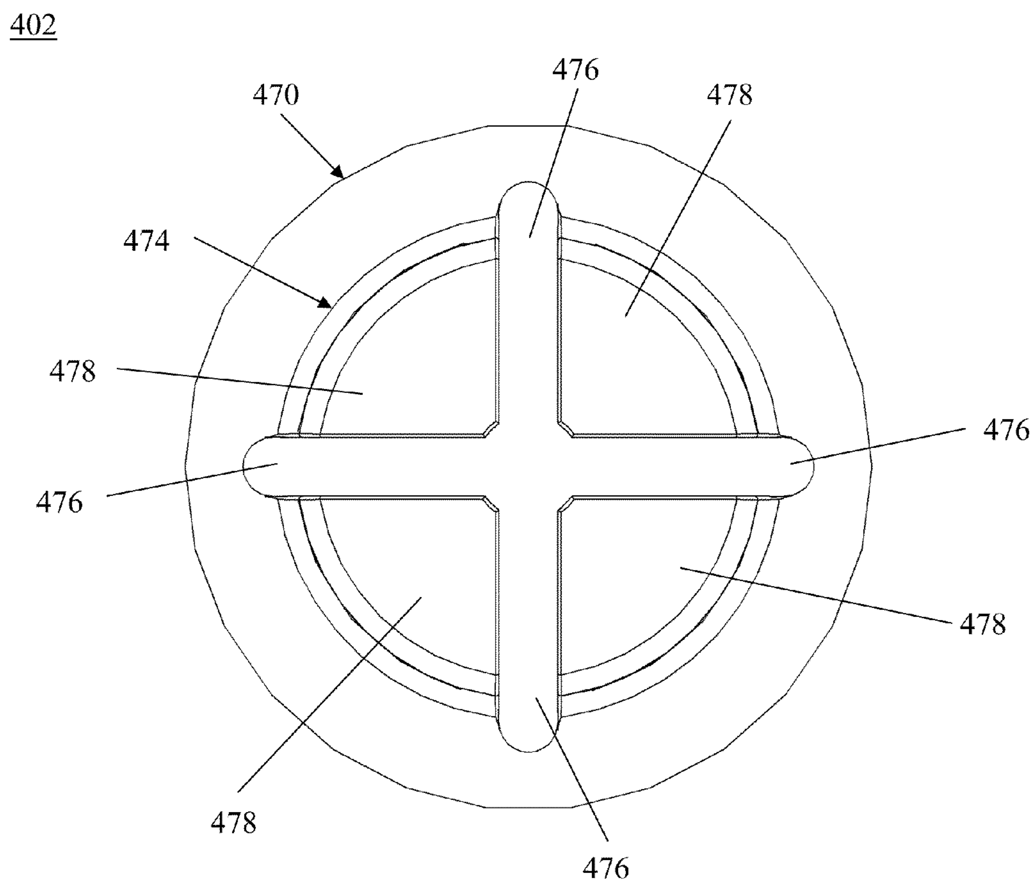

FIG. 57

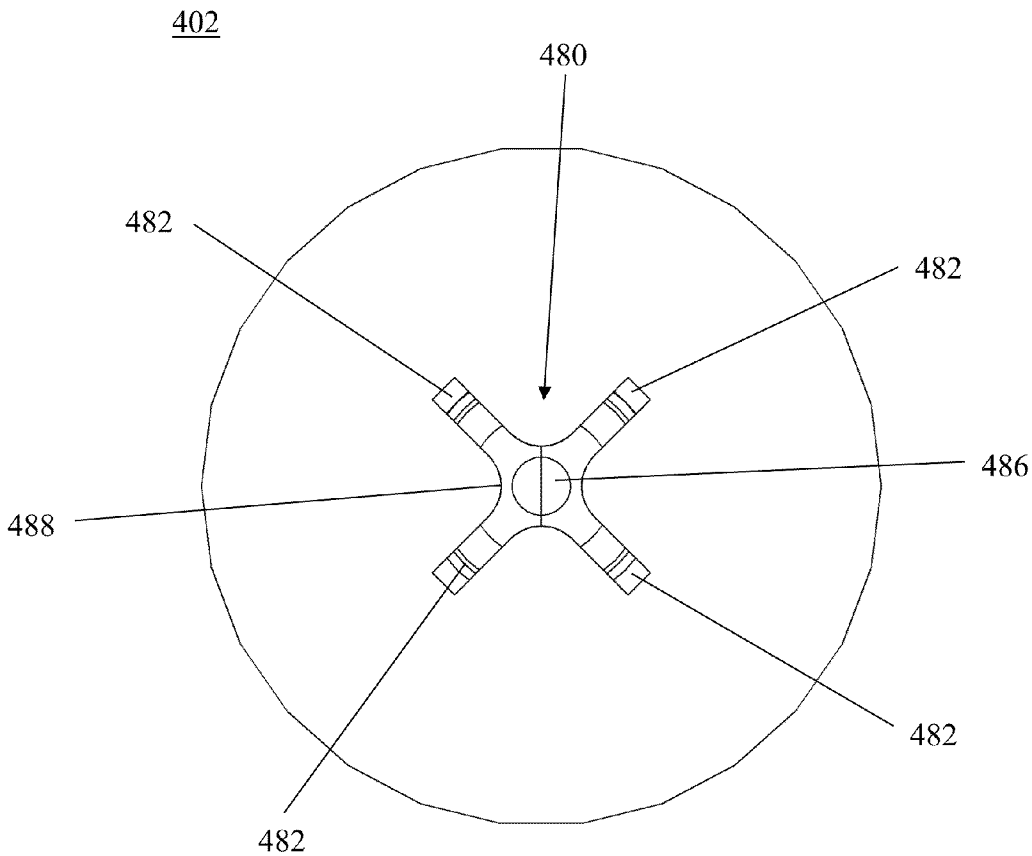

FIG. 58

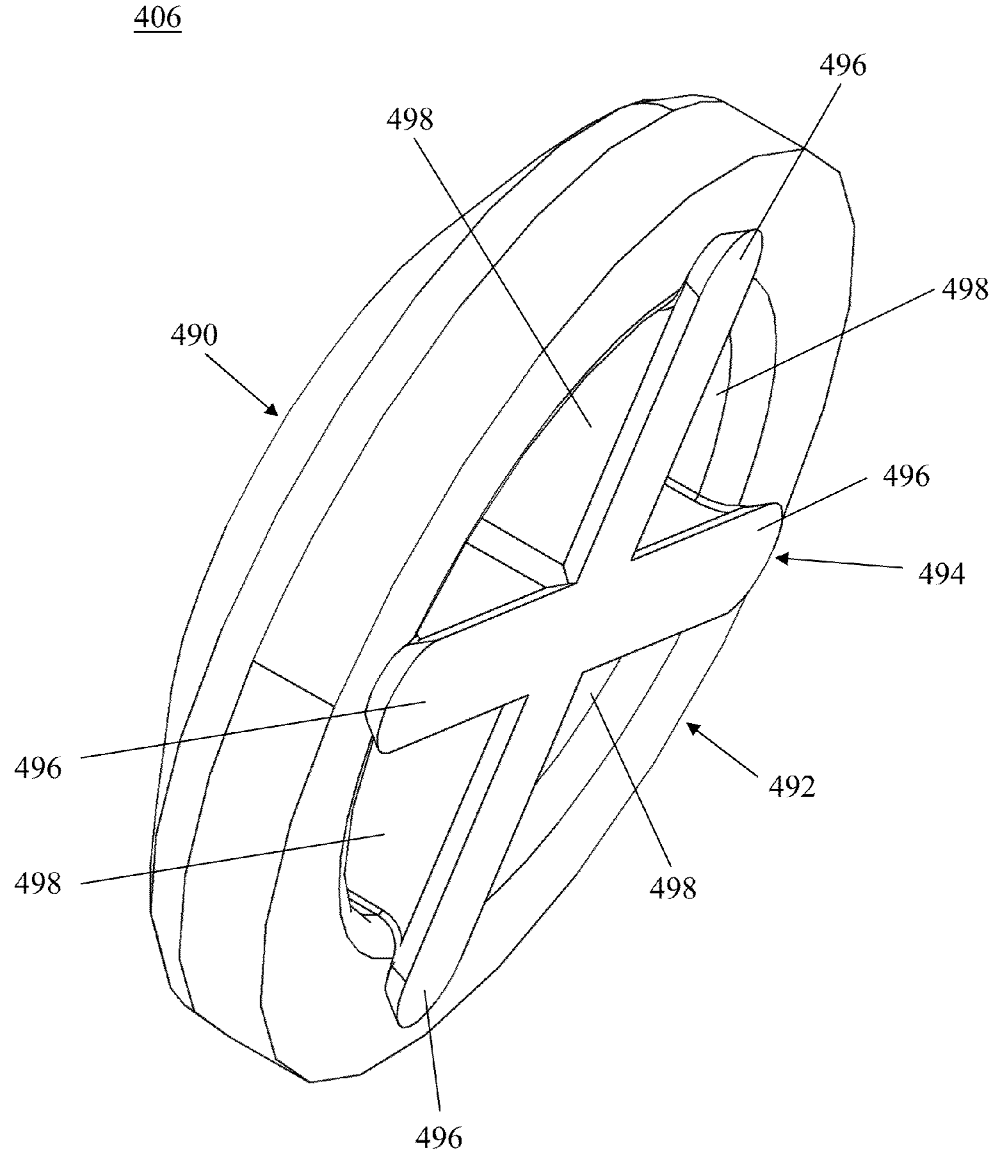

FIG. 59

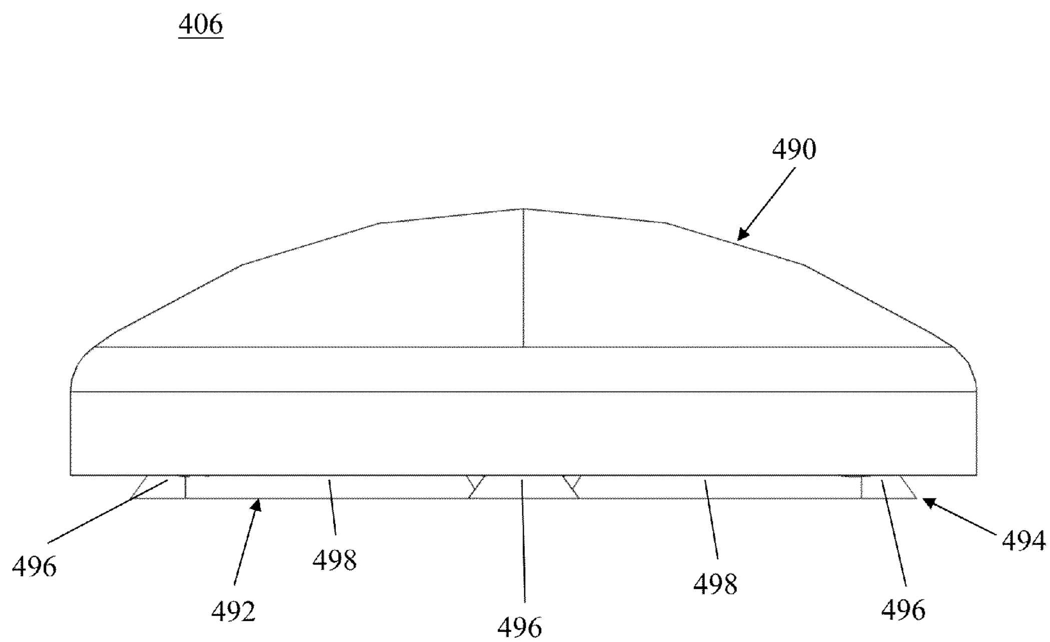

FIG. 60

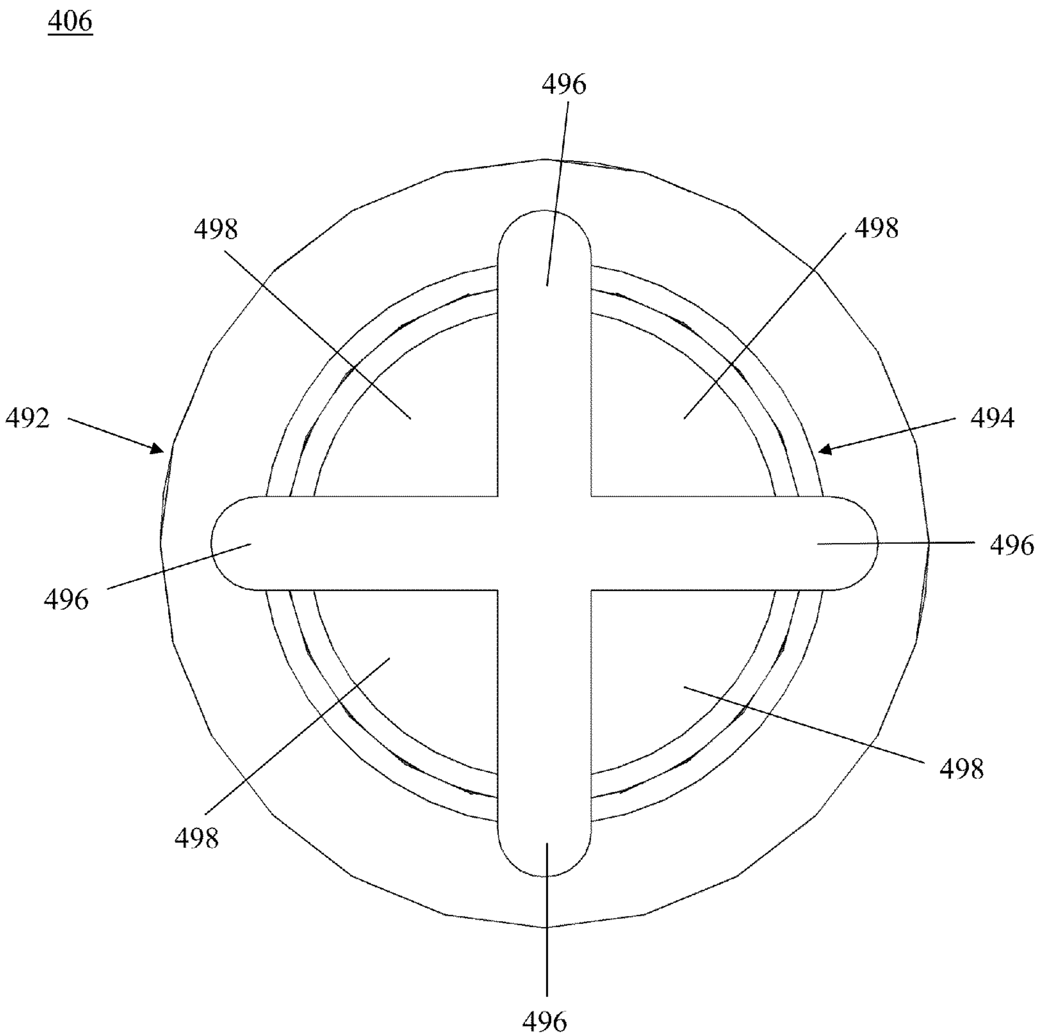

FIG. 61

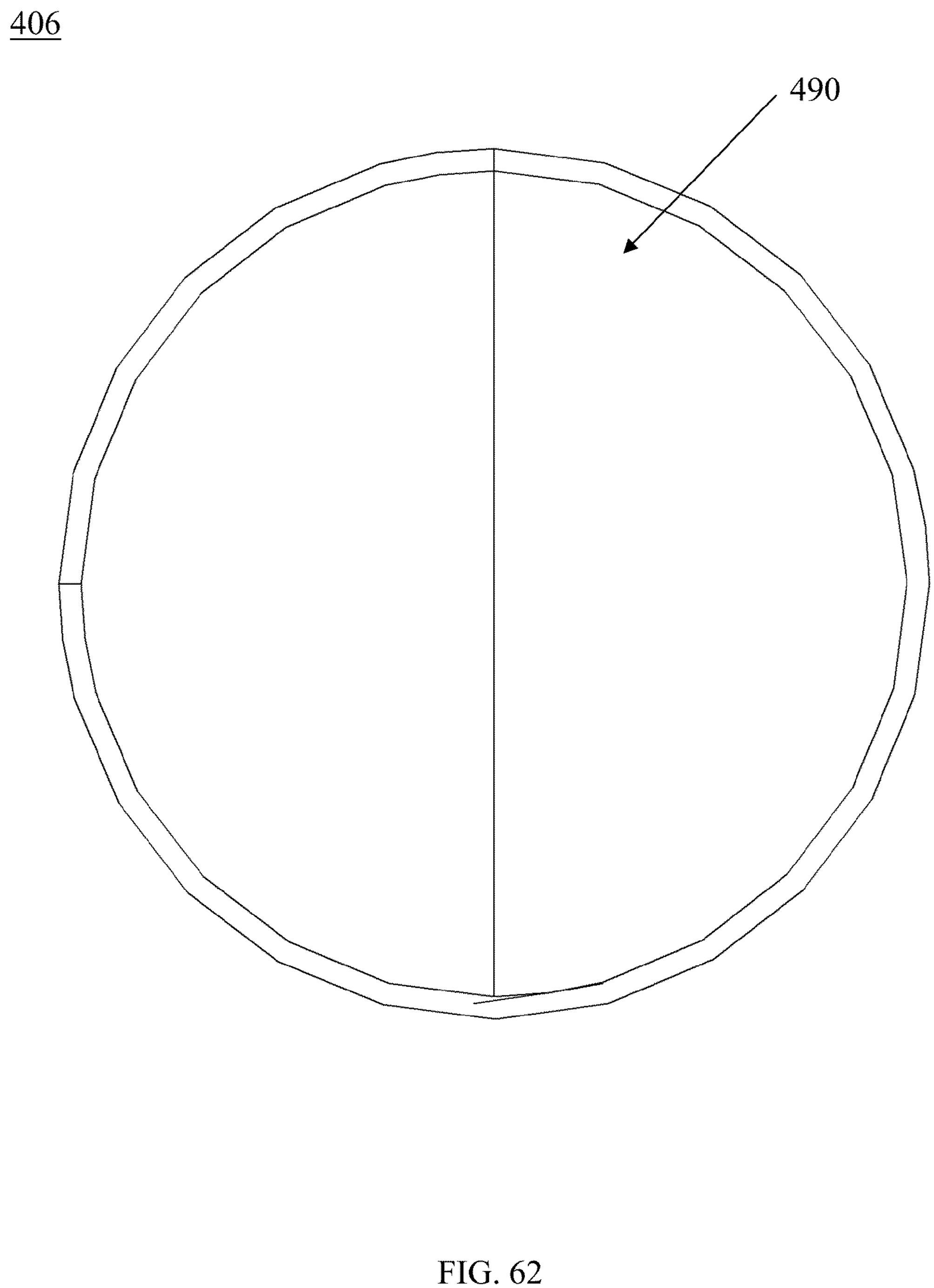

FIG. 62

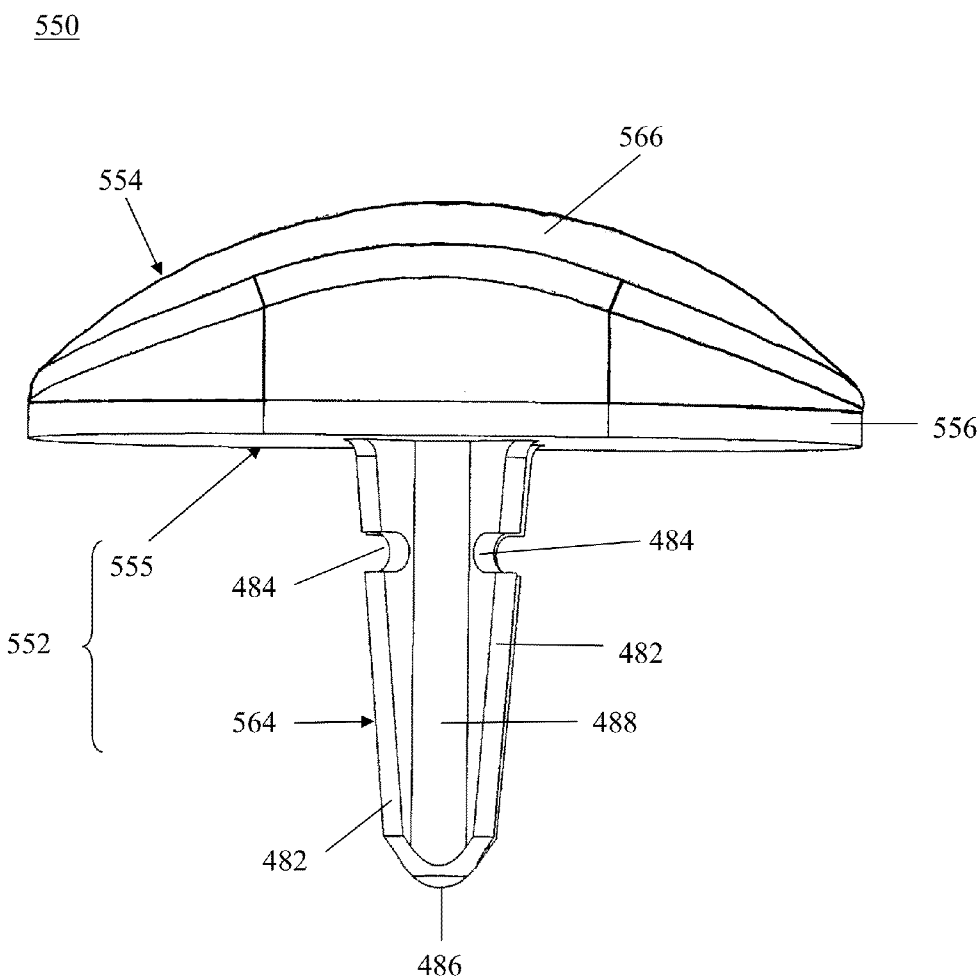

FIG. 63

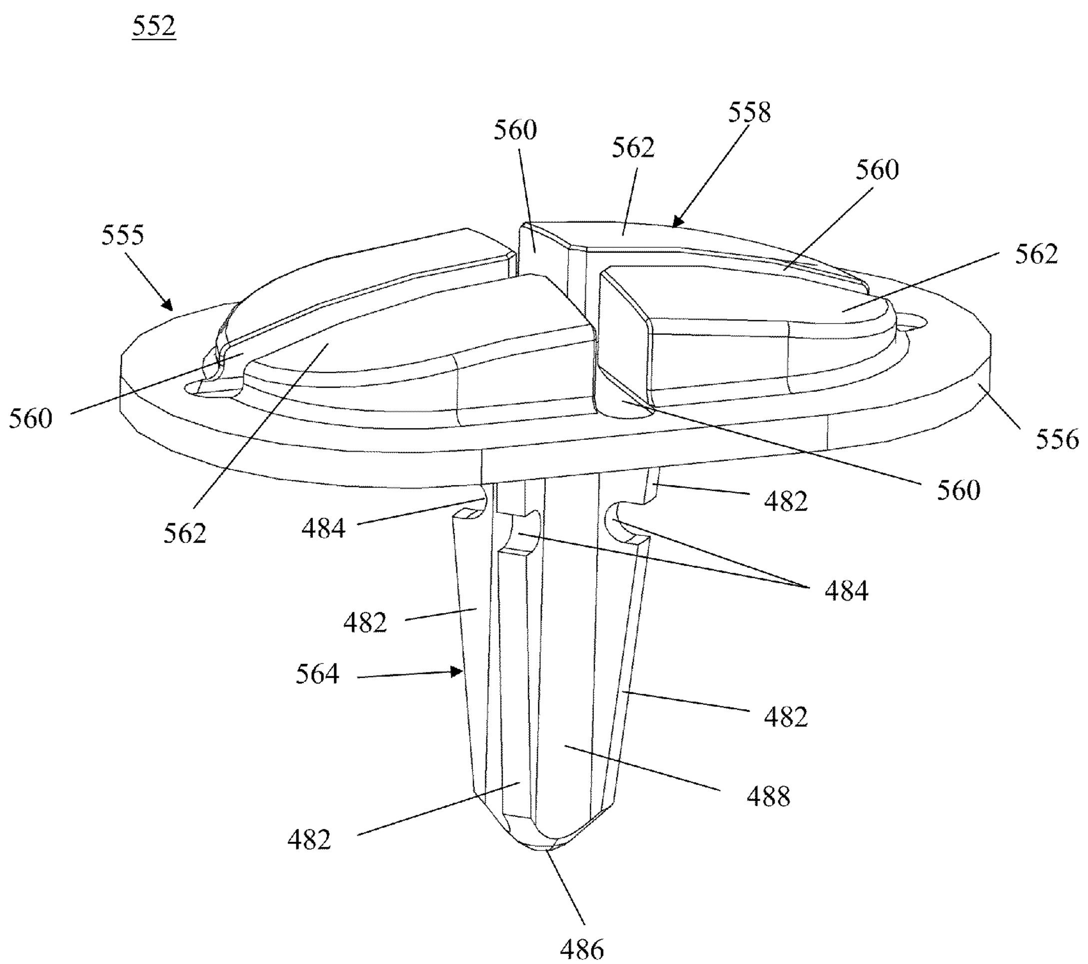
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FIG. 64

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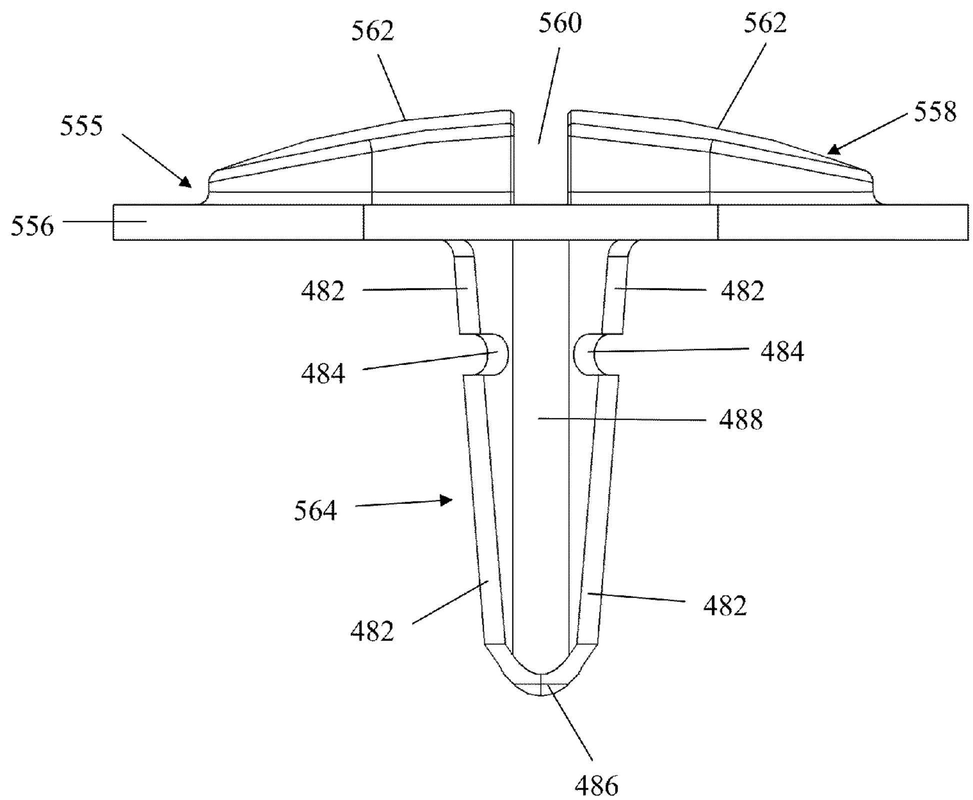

FIG. 65

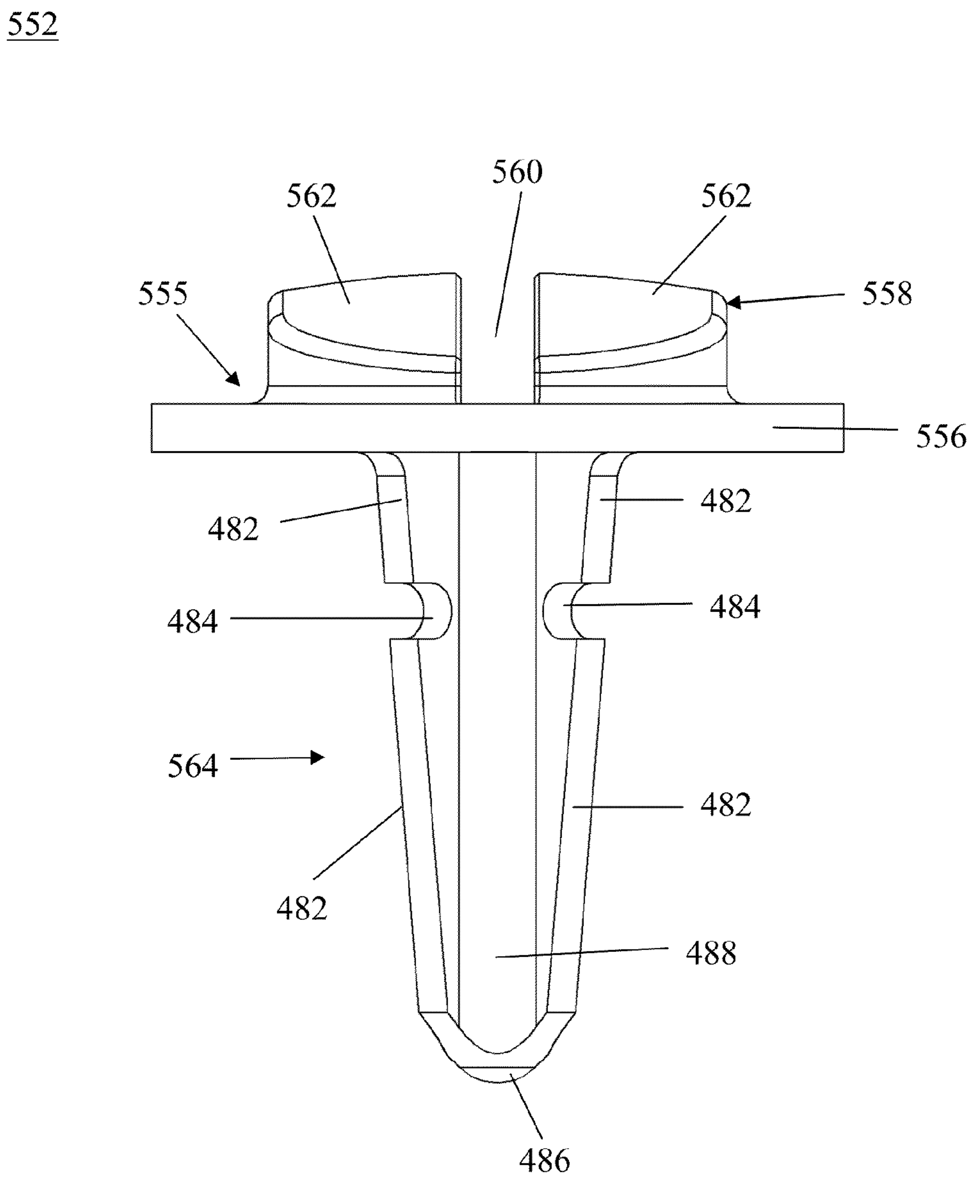

FIG. 66

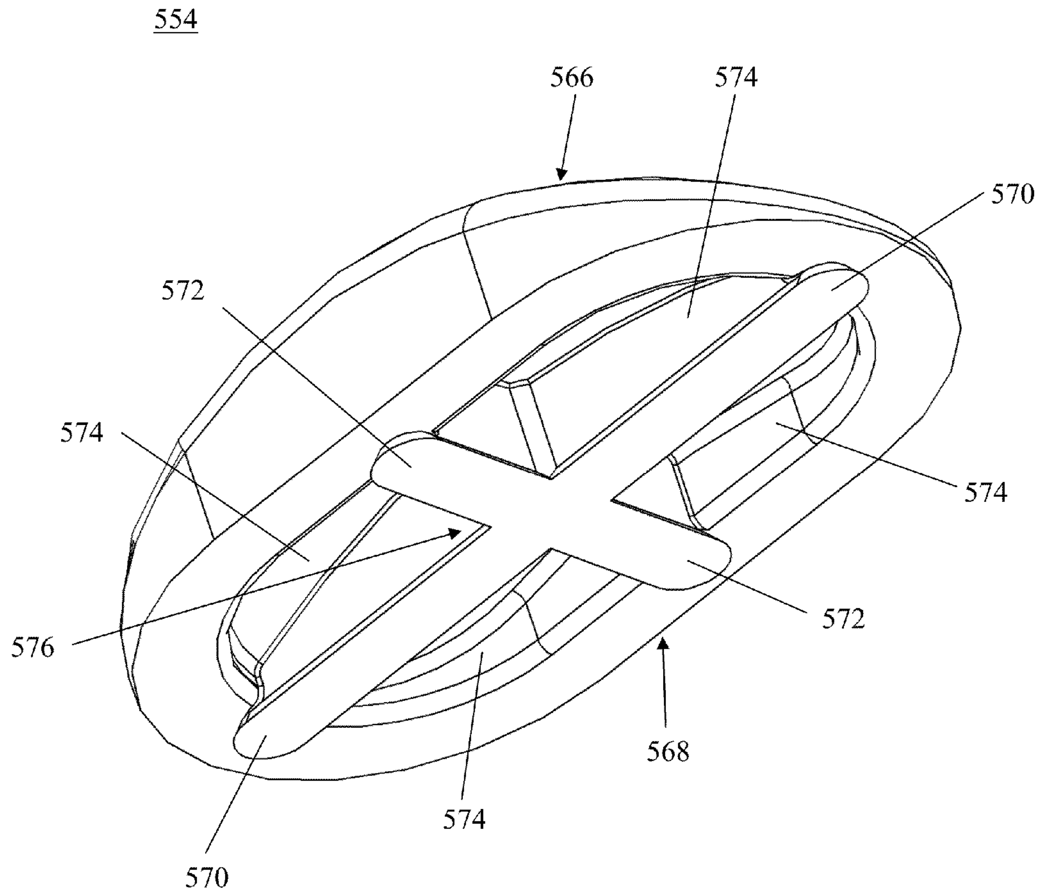

FIG. 67

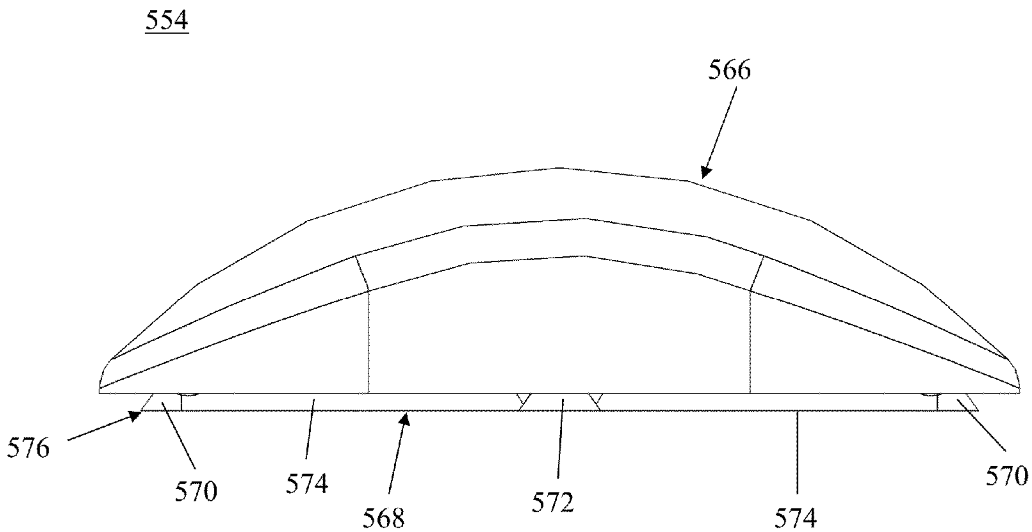

FIG. 68

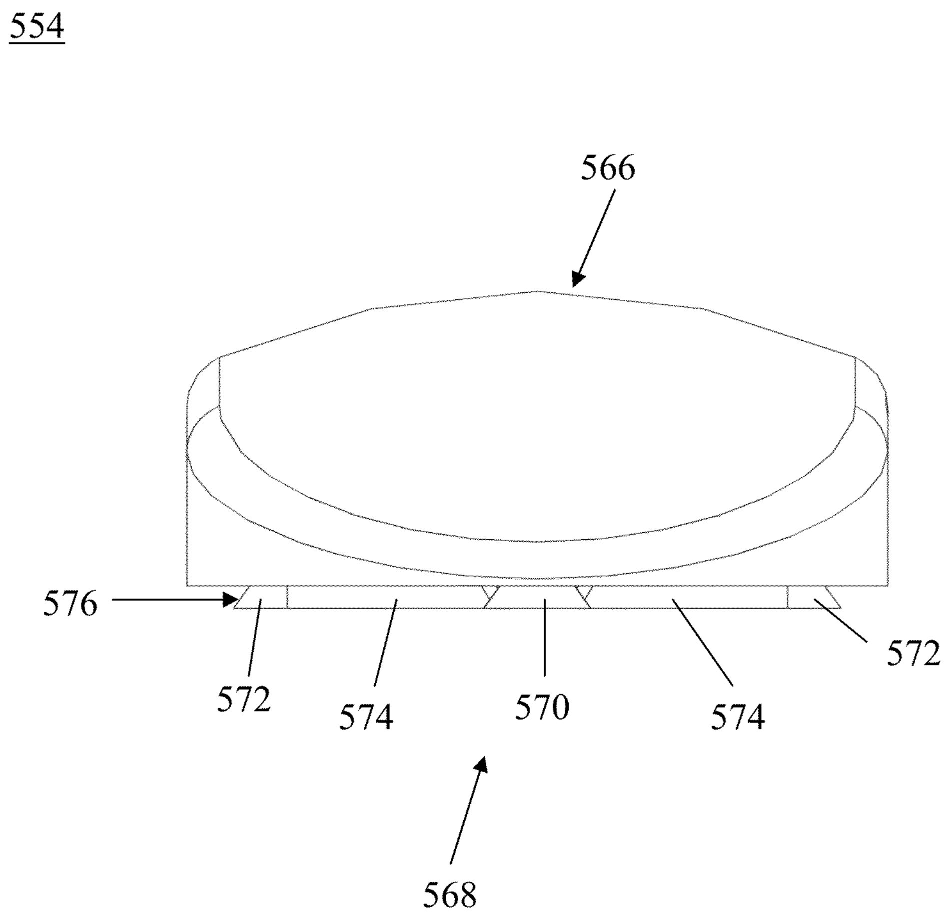

FIG. 69

PARTIAL JOINT RESURFACING IMPLANT, INSTRUMENTATION, AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part application of U.S. application Ser. No. 12/919,607 filed Sep. 10, 2010, which is a national stage filing under section 371 of International Application No. PCT/US2009/034826 filed on Feb. 23, 2009 and published in English as WO 2009/108591 on Sep. 3, 2009 and claims priority to U.S. Provisional Application No. 61/032,141 filed Feb. 28, 2008, the entire disclosure of these applications being hereby incorporated herein by reference.

TECHNICAL FIELD

The present invention relates generally to surgical devices for use in partial resurfacing of damaged or diseased articular cartilage of the joints and to surgical methods using such devices.

BACKGROUND OF THE INVENTION

Articular cartilage, or hyaline type cartilage, is a unique tissue providing a smooth, lubricious, hydrophilic, load bearing covering on the ends of bones in diarthroidal joints, in particular the knee, hip, shoulder, to name a few. This tissue is susceptible to damage or deterioration caused by excessive loading resulting in inflammation, pain, swelling, and joint dysfunction. As a result many methods have been developed to clinically treat patients when cartilage degeneration occurs.

Articular cartilage, or hyaline type cartilage, is a unique tissue providing a smooth, lubricious, hydrophilic, load bearing covering on the ends of bones in diarthroidal joints, in particular the knee, hip, shoulder, to name a few. This tissue is susceptible to damage or deterioration caused by excessive loading resulting in inflammation, pain, swelling, and joint dysfunction. As a result many methods have been developed to clinically treat articular cartilage defects.

For smaller cartilage defects surgical techniques have been used to stimulate an intrinsic repair process. These include drilling, abrasion and microfracture of the subchondral bone which induces bleeding resulting in the formation of a new fibrocartilage covering. Unfortunately the biomechanical properties of this tissue is not equivalent to the original hyaline cartilage, and over time the repair tissue is prone to wear, many times resulting in osteoarthritis.

Alternatively, an osteo-articular transfer system (OATS) procedure may be done, especially as the defect size increases. This technique involves coring a plug of cartilage and subchondral bone from a non weight bearing area of the bone and implanting it to a prepared hole in the defect area. One or multiple plugs can be used to fill the defect area. This procedure is technically difficult as the cored bone/cartilage plugs must be accurately placed to create the new contiguous articulating surface. Leaving the surface of the plugs too high or low can significantly compromise the surgical outcome. Due to the multiple drilling locations and angles needed, this procedure is typically done with an open surgical technique followed by a lengthy rehabilitation schedule.

Autologus chondrocyte implantation is a transfer type system where cartilage cells are harvested in one surgical procedure, expanded in a laboratory, and then injected into the prepared defect site in a second surgery. While clinical outcomes are reported to be similar to the above described techniques this procedure is extremely expensive, requires two surgeries (one of which is a challenging open procedure), and similar long rehabilitation schedule.

Other biological attempts have been made to treat larger cartilage defects with tissue engineered bioabsorbable scaffold systems. Unfortunately they have not shown clinical outcomes advantageous to the above described techniques.

For many larger defects in the knee the only option available is to treat these defects nonoperatively in an endeavor to control symptoms until a unicompartmental knee replacement (UKR) or total knee replacement (TKR) is accomplished. With these devices both articulating bone ends are removed and replaced with metal and an ultrahigh molecular weight polyethylene insert (with or without a metal backing) is placed between the two metallic pieces. In a UKR both bone ends of the medial or lateral half of the knee are replaced whereas with a TKR both halves (and patella) are replaced. These prosthetic devices require an invasive, technically demanding implantation procedure and a long, involved, and painful rehabilitation period. Further, these devices are often larger than the defective tissue that needs to be replaced, so healthy bone and cartilage are sacrificed to accommodate the implants. Albeit that modern UKR and TKR devices are much improved from early hinged knee prostheses, there is still a loss of joint kinematics as this normal tissue is removed. Additionally, the lifetime of TKRs is limited by a variety of implant and patient-related factors resulting in many patients outliving their primary prosthetic device, thus requiring a more difficult revision TKR surgery. To avoid this eventual revision surgery many younger patients will endure the pain and limited use these defects cause in order to put off the TKR procedure as long as possible. It should be noted that the same events occur in the hip and shoulder joints as well.

Implants constructed using measurements obtained from a defect have also been used. The installed implant thus attempts to closely match the shape of the defective area and articulate directly with the opposing native cartilage surface. This device has operative advantages over traditional knee prostheses; however, the opposing articular cartilage is prone to damage due to the large differences in material properties and is further exacerbated by any contour mismatching.

Similarly, metals, usually cobalt-chromium or titanium alloys, have been used for the surface of hip hemiarthroplasties. These prosthetic devices replace only the femoral side of the hip joint and articulate against the facing cartilage of the acetabulum. These metal implants have exhibited adverse effects on the cartilage against which they articulate causing erosion of the facing cartilage in several clinical studies. Thus, merely matching the anatomical shape of the cartilage that is resurfaced is not enough to prevent damage of the facing cartilage by a metallic counterface.

Several researchers have tried using lower modulus polymeric materials, such as high density or ultra high molecular weight polyethylene (UHMWPE), for the surface of hemiarthroplasty implants on the theory that a material with mechanical properties more closely matched to those of cartilage would cause less cartilage damage. These implants also caused erosion of the facing cartilage in vivo likely due to a mismatch in surface chemistry properties, (i.e. UHMWPE is hydrophobic and cartilage is hydrophilic). Thus, lower modulus implants alone are not enough to prevent damage of the facing cartilage.

Accordingly there is a need for an improved cartilage replacement system that would be effective in restoring a smooth, lubricious, and hydrophilic load bearing surface, with a modulus less than traditional metals, that can be easily implanted with minimal normal tissue removal, and requires a less involved rehabilitation schedule ultimately restoring joint kinematics while avoiding damage to the opposing cartilage surface.

SUMMARY OF THE INVENTION

Advancement of the state of surgical repair of damaged or diseased articular cartilage of joints is desirable. The present invention satisfies the need for improvements to implants and corresponding surgical instruments used to insert such implants in patients who have either diseased or damaged articular cartilage by providing a partial resurfacing implant and instrument system that allows the operating surgeon to insert, with accuracy, an implant that maximizes defect coverage while minimizing host bone and cartilage removal.

The present invention provides in one aspect, a surgical method for repairing an articular cartilage defect site. The method generally includes the step of surgically creating an opening in the articular cartilage defect site. The method may include the step of using a partial resurfacing implant in the defect site. The implant includes a top articulating portion and supporting plate. The supporting plate generally includes a top surface and a bottom surface. The top surface of the supporting plate is attached in some manner to the top articulating portion with the bottom surface of the supporting plate being constructed to assist in the insertion of the implant into the articular cartilage defect site. The method may also include the step of implanting the partial resurfacing implant into the defect site opening. Usually, when upon inserting the implant into the defect site, the top articulating portion and adjacent articular cartilage may be positioned tangential or adjacent to each other which allows for unrestricted motion over the defect site while allowing for load transfer to occur through the implant to the underlying bone.

The present invention provides in another aspect, a surgical method for repairing an articular cartilage defect site. The method generally includes the step of measuring the size of the articular cartilage defect site. The method may include the step of aligning a drill guide over the articular cartilage defect site. The method may also include the step of inserting a pilot drill bit into the drill guide and using the pilot drill bit to form at least one pilot hole in the articular cartilage defect site. The at least one pilot hole may be oriented substantially normal to the articular cartilage defect site. Once the pilot drill bit is secured to the bone the drill guide may be removed. The method may include the steps of enlarging the at least one pilot hole to accommodate a partial resurfacing implant. The method may further include the step of inserting a trial implant into the articular cartilage defect site to confirm the sizing and final positioning of the partial resurfacing implant. When the correct size trial implant is inserted into the articular cartilage defect site, the size of the trial implant may then be used to select the partial resurfacing implant. The method may also include the step of inserting the partial resurfacing implant into the articular cartilage defect site. Usually, when inserting the implant into the defect site, a top portion of the partial resurfacing implant and adjacent articular cartilage may be positioned tangential or adjacent to each other to facilitate motion over the defect site while allowing for load transfer to occur through the implant to the underlying bone.

The present invention provides in yet another aspect, an implant for repairing an articular cartilage defect site. The implant includes a top articulating portion with an articulating surface and an engagement surface. The implant fixation portion includes an upper segment and at least one bone interfacing segment. The upper segment of the implant fixation portion is coupled to the top articulating portion. The at least one bone interfacing segment of the implant fixation system is configured to facilitate insertion into the articular cartilage defect site. The implant also includes a locking mechanism. The locking mechanism includes at least two perpendicular protrusions with tapered edges on the engagement surface of the top articulating portion and at least two channels on the upper segment of the implant fixation portion. The at least two channels of the implant fixation portion engage the at least two protrusions of the top articulating portion to secure the top articulating portion to the implant fixation portion.

Further, additional features, benefits and advantages of the present invention will become apparent from the drawings and descriptions contained therein. Other embodiments and aspects of the invention are described in detail herein and are considered a part of the claimed invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a perspective view of a distal condyle of a human femur with a cartilage defect, in accordance with an aspect of the present invention;

FIG. **2** is a perspective side view of one embodiment of a cartilage resurfacing implant, in accordance with an aspect of the present invention;

FIG. **3** is a perspective side view of a second embodiment of a cartilage resurfacing implant with a single implant fixation portion, in accordance with an aspect of the present invention;

FIG. **4** is a perspective side view of the second embodiment of a cartilage resurfacing implant of FIG. **3** with multiple implant fixation portions, in accordance with an aspect of the present invention;

FIG. **5** is a distal view of one embodiment of multiple cartilage resurfacing implants positioned adjacent to each other, in accordance with an aspect of the present invention;

FIG. **6** is a perspective view of one embodiment of an anatomical drill guide, in accordance with an aspect of the present invention;

FIG. **7** is a perspective view of one embodiment of a pronged anatomical drill guide, in accordance with an aspect of the present invention;

FIG. **8** is a perspective view of one embodiment of a multi-axis anatomical drill guide, in accordance with an aspect of the present invention;

FIG. **9** is a side view of one embodiment of an anatomical drill guide positioned on the distal aspect of a femoral condyle, in accordance with an aspect of the present invention;

FIG. **10** is a side sectional view of a cartilage cutting instrument, in accordance with an aspect of the present invention;

FIG. **11** is an enlarged side sectional view of the distal end of the cartilage cutting instrument of FIG. **10** positioned adjacent to the femoral condyle, in accordance with an aspect of the present invention;

FIG. **12** is a sectional side view of a prepared defect site at the distal aspect of the femoral condyle, in accordance with an aspect of the present invention;

FIG. **13** is a perspective view of a trial implant before insertion into a prepared defect site, in accordance with an aspect of the present invention;

FIG. **14** is a perspective view of an implant insertion instrument, in accordance with an aspect of the present invention;

FIG. **15** is a perspective view of the resurfacing implant of FIG. **2** seated within the prepared defect side in the distal aspect of the femoral condyle, in accordance with an aspect of the present invention;

FIG. **16** is a top view of the cartilage resurfacing implant of FIG. **4**, in accordance with an aspect of the present invention;

FIG. **17** is a perspective view of the distal aspect of a femur with an attached dual hole drill guide, in accordance with an aspect of the present invention;

FIG. **18** is a perspective view of the distal aspect of a femur with dual pilot drills positioned within the drill guide of FIG. **15**, in accordance with an aspect of the present invention;

FIG. **19** is a perspective view of the distal aspect of a femur with dual pilot drills positioned within the drill guide of FIG. **15**, in accordance with an aspect of the present invention;

FIG. **20** is a perspective view of the distal aspect of a femur with one of the dual pilot drills remaining following removal of the second pilot drill, in accordance with an aspect of the present invention;

FIG. **21** is a perspective view of the distal aspect of a femur with a cutting cannula assembly placed over the single pilot drill, in accordance with an aspect of the present invention;

FIG. **22** is a perspective view of an inner support member being removed from the cutting cannula of FIG. **21**, in accordance with an aspect of the present invention;

FIG. **23** is a perspective view of a cannulated reamer being placed over a single pilot drill, in accordance with an aspect of the present invention;

FIG. **24** is a perspective view of the distal femur being reamed with the cannulated reamer of FIG. **23**, in accordance with an aspect of the present invention;

FIG. **25** is a perspective view of the re-insertion of a second pilot drill into the posterior hole and placement of a cutting tube guide, in accordance with an aspect of the present invention;

FIG. **26** is a perspective view of the cutting cannula inserted over the second pilot drill and abutting cutting tube guide, in accordance with an aspect of the present invention;

FIG. **27** is a perspective view of an inner support member being removed from the cutting cannula of FIG. **26**, in accordance with an aspect of the present invention;

FIG. **28** is a perspective view of the cannulated reamer being placed over the second pilot drill, in accordance with an aspect of the present invention;

FIG. **29** is a perspective view of the cannulated reamer removing bone from the distal femur, in accordance with an aspect of the present invention;

FIG. **30** is a perspective view of the prepared defect site in the distal femur, in accordance with an aspect of the present invention;

FIG. **31** is a superior view of a third embodiment of a cartilage replacement implant, in accordance with an aspect of the present invention;

FIG. **32** is a perspective view of the prepared defect site in the distal femur following the removal of the cartilage flaps, in accordance with an aspect of the present invention;

FIG. **33** is a perspective view of the insertion of a trial sizing instrument inserted into the prepared defect site of FIG. **32**, in accordance with an aspect of the present invention;

FIG. **34** is a perspective view of the insertion of the cartilage replacement implant of FIG. **4** prior to final implantation into the distal femur, in accordance with an aspect of the present invention;

FIG. **35** is a perspective view of the insertion of a trial-drill guide for the cartilage resurfacing implant of FIG. **3**, in accordance with an aspect of the present invention;

FIG. **36**A is a perspective view of the prepare defect site after the removal of the trial-drill guide of FIG. **35**, in accordance with an aspect of the present invention;

FIG. **36**B is a perspective view of the insertion of the cartilage replacement implant of FIG. **3** prior to final implantation into the distal femur, in accordance with an aspect of the present invention;

FIG. **37** is a perspective view of another embodiment cutting cannula including a depth collar, in accordance with an aspect of the present invention;

FIG. **38** is a perspective view of the distal aspect of a femur with a trial sizing instrument placed over the defect site, in accordance with an aspect of the present invention;

FIG. **39** is a perspective view of the distal aspect of a femur with a depth probe inserted into the defect site, in accordance with an aspect of the present invention;

FIG. **40** is a perspective view of the distal aspect of a femur with an attached drill guide, in accordance with an aspect of the present invention;

FIG. **41** is a perspective view of the distal aspect of a femur with a pilot drill being inserted into the drill guide of FIG. **40**, in accordance with an aspect of the present invention;

FIG. **42** is a perspective view of the distal aspect of a femur with dual pilot drills being inserted into an alternative drill guide, in accordance with an aspect of the present invention;

FIG. **43** is a perspective view of the distal aspect of a femur with a guide tube inserted onto the pilot drill and a cutting cannula being inserted onto the guide tube, in accordance with an aspect of the present invention;

FIG. **44** is a perspective view of the distal aspect of a femur with a guide tube being removed from a reamer depth tube, in accordance with an aspect of the present invention;

FIG. **45**A is a perspective view of the distal aspect of a femur with a cannulated bone reamer being inserted into a reamer depth tube, in accordance with an aspect of the present invention;

FIG. **45**B is a partial view of the tip of the reamer depth tube of FIGS. **44** and **45**A, in accordance with an aspect of the present invention;

FIG. **46** is a perspective view of the distal aspect of a femur with a drill bit inserted into a prepared defect site, in accordance with an aspect of the present invention;

FIG. **47** is a perspective view of the distal aspect of a femur showing another prepared defect site, in accordance with an aspect of the present invention;

FIG. **48** is a perspective view of the distal aspect of a femur with a trial being inserted over the drill bit, in accordance with an aspect of the present invention;

FIG. **49** is a perspective view of the distal aspect of a femur with another embodiment trial being inserted into the prepared defect site, in accordance with an aspect of the present invention;

FIG. **50** is a perspective view of the distal aspect of a femur with an implant being inserted into a prepared defect site, in accordance with an aspect of the present invention;

FIG. **51** is a perspective view of the distal aspect of a femur with an alternative embodiment implant being inserted into a prepared defect site, in accordance with an aspect of the present invention;

FIG. **52** is a perspective view of the distal aspect of a femur with the implant of FIG. **50** inserted into a prepared defect site, in accordance with an aspect of the present invention;

FIG. **53** is a perspective view of the distal aspect of a femur with the implant of FIG. **51** inserted into a prepared defect site, in accordance with an aspect of the present invention;

FIG. **54** is an alternative embodiment of a cartilage resurfacing implant, in accordance with an aspect of the present invention;

FIG. **55** is an isometric top lateral view of an implant fixation portion of the cartilage resurfacing implant of FIG. **54**, in accordance with an aspect of the present invention;

FIG. **56** is a lateral view of the implant fixation portion of FIG. **55**, in accordance with an aspect of the present invention;

FIG. **57** is a top view of the implant fixation portion of FIG. **55**, in accordance with an aspect of the present invention;

FIG. **58** is a bottom view of the implant fixation portion of FIG. **55**, in accordance with an aspect of the present invention;

FIG. **59** is an isometric bottom side view of an bearing portion of the cartilage resurfacing implant of FIG. **54**, in accordance with an aspect of the present invention;

FIG. **60** is a side view of the bearing portion of FIG. **59**, in accordance with an aspect of the present invention;

FIG. **61** is a bottom view of the bearing portion of FIG. **59**, in accordance with an aspect of the present invention;

FIG. **62** is a top view of the bearing portion of FIG. **59**, in accordance with an aspect of the present invention;

FIG. **63** is a further alternative embodiment of a cartilage resurfacing implant, in accordance with an aspect of the present invention;

FIG. **64** is an isometric top lateral view of an implant fixation portion of the cartilage resurfacing implant of FIG. **63**, in accordance with an aspect of the present invention;

FIG. **65** is a lateral view of the implant fixation portion of FIG. **64**, in accordance with an aspect of the present invention;

FIG. **66** is an anterior view of the implant fixation portion of FIG. **64**, in accordance with an aspect of the present invention;

FIG. **67** is an isometric bottom side view of a bearing portion of the cartilage resurfacing implant of FIG. **63**, in accordance with an aspect of the present invention;

FIG. **68** is a lateral view of the bearing portion of FIG. **67**, in accordance with an aspect of the present invention;

FIG. **69** is an anterior view of the bearing portion of FIG. **67**, in accordance with an aspect of the present invention.

DETAILED DESCRIPTION FOR CARRYING OUT THE INVENTION

For the purposes of promoting an understanding of the principles of the partial joint resurfacing implant, corresponding surgical instruments and surgical method for inserting the resurfacing implant, reference will now be made to the embodiments, or examples, illustrated in the drawings and specific language will be used to describe these. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the multi-functional surgical instrument invention relates.

In this detailed description and the following claims, the words proximal, distal, anterior, posterior, medial, lateral, superior and inferior are defined by their standard usage for indicating a particular part of a bone, prosthesis or surgical instrument according to the relative disposition of the surgical instrument or directional terms of reference. For example, "proximal" means the portion of an implant or instrument positioned nearest the torso, while "distal" indicates the part of the implant or instrument farthest from the torso. As for directional terms, "anterior" is a direction towards the front side of the body, "posterior" means a direction towards the back side of the body, "medial" means towards the midline of the body, "lateral" is a direction towards the sides or away from the midline of the body, "superior" means a direction above and "inferior" means a direction below another object or structure.

As used herein, the terms "partial joint resurfacing implant," "surfacing implant" and "implant" may be used interchangeably as they essentially describe the same type of implantable device.

Referring to FIG. **1**, cartilage defects **29** in the knee, and more specifically within the femoral condyle **5***a* and other joints, occur as a result of wear and/or mechanical overloading. They occur in varying sizes and shapes and tend to progress to larger defects if left untreated. To reduce or eliminate the pain caused by these defects and to decrease or eliminate the progression of the joint deterioration, the damaged cartilage with a portion of underlying bone is removed and replaced with a device providing a new articulating surface and an anchor into the bone.

Referring to FIG. **2**, a generally cylindrical implant **30***b* of the present invention is shown for example purposes only. The top articulating portion **30** is made from a material that has a lower modulus of elasticity then traditional metal implants. In this embodiment, top articulating portion **30** consists of a polymeric smooth, lubricious, and hydrophilic top surface **30***a* fabricated from a polysaccharide-treated thermoplastic polymer material capable of withstanding in vivo loading. This articulating surface material is more fully described in patent application Ser. No. 10/283,760 that is herein incorporated by reference. It should be noted that other biocompatible materials may be used to fabricate top articulating portion **30**, that include, but are not limited to: polysaccharide treated thermoplastic polymers including polysaccharides such as hyaluronic acid, chitosan, thermoplastic polymers such as UHMWPE and other aliphatic polymers like polypropylene, polybutylene, polyethylene-butylene rubber. Also other thermoplastic polymers such as polyurethanes, polysiloxanes, polyesters, are contemplated for use. Additional other materials to fabricate top articulating portion **30** may include polyesters such as PET (polyethylene terephthalate); perfluorinated hydrocarbons [e.g. teflon]; acrylates [e.g. PMMA (polymethyl methacrylate), polyacrylonitrile, polyacrylomide]; polyamides (e.g. nylon); polycarbonate; epoxy resins; PEEK (polyether ether ketone); ceramics; polysiloxanes (e.g. silicone resins); metals (e.g. cobalt chrome, titanium and titanium alloys, stainless steel); and hydrogels (e.g. polyvinyl alcohol).

The implant fixation portion **31** of the implant can be constructed of metal, polymer, composite or other biocompatible resorbable or non-resorbable material including, but not limited to, Co—Cr, Ti Alloy, PEEK, UHMWPE or alternatively, entirely from the same material that makes up top articulating portion **30**.

As shown in FIG. **2**, implant **30***b* further includes supporting plate **32** that has a locking mechanism **33** to securely couple top articulating portion **30**.

The bone interfacing portion of implant fixation portion **31** that extends from supporting plate **32** can be treated or contains features to permit bony ingrowth from the bone bed in which it is implanted. It is contemplated that implant fixation portion **31** may include a lower stem **34** portion containing fixation barbs **35**, threads or fins (not shown) to lock implant **30***b* into bone. Although not shown, other bone fixation members that project from the undersurface of supporting plate **32** are contemplated and may include tapered stems, straight pegs or a plurality of pegs. It is also contemplated that implant fixation portion **31** and the bottom surface of supporting plate **32** could also have a coating or finish to assist with bone integration, such as HA, TCP or BMP coating, titanium plasma spray, grit blasting, or any other operation that roughens the surface of the structure. It is understood that the construct of implant **30***b* as shown in FIG. **2** will minimize the amount of resected bone which is advantageous for reducing trauma to the remaining healthy surrounding bone, reducing healing time, and will permit later removal without compromising total joint arthroplasty efficacy at that time. It is further understood by one skilled in the art that implant **30***b* may be constructed without implant fixation portion **31**. It is contemplated that for such a construct the bottom surface of supporting plate **32** may be coated or finished using the above-named techniques to enhance or assist with bone integration. An embodiment constructed without implant fixation portion **31** may be used in various clinical situations when a projecting structure is deemed unnecessary.

Top articulating portion **30** of implant **30***b* is commonly fabricated using direct compression molding techniques to overmold supporting plate **32** resulting in a final construct where top articulating portion **30** is securely adhered to supporting plate **32** via locking mechanism **33**.

As described previously, top portion **30** is attached to supporting plate **32** via locking mechanism **33** which for example purposes is configured as an undercut dovetail locking arrangement. The angle of the two vertical walls of the dovetail locking arrangement are generally less than **90** degrees, which provides resistance against top articulating portion **30** from dislodging superiorly. The nature of the dovetail feature may also prevent top articulating portion **30** from rotating relative to the supporting plate **32**. Additionally, locking mechanism **33** may include two dovetail cuts perpendicular to each other, resulting in a cross-shaped arrangement if viewed from a superior perspective. Having multiple directional cuts helps to ensure that there is no translational or sliding movement of top articulating portion **30** relative to supporting plate **32**. Alternative modes of fixing top articulating portion **30** to supporting plate **32** may also include a snap-fit mechanism, an adhesive material or an alternative locking channel.

The bottom aspect of implant **30***b* is generally a one-piece construct that is made up of two different constructs, supporting plate **32** that holds and supports top articulating portion **30**, and implant fixation portion **31** that functions to provide stability and fixation within the host bone. Supporting plate **32** includes a generally flat bottom surface to which implant fixation portion **31** is integrally connected. The top surface of supporting plate **32** may also be generally flat as well, not withstanding locking mechanism **33** that is disposed thereon. Implant fixation portion **31** includes a generally cylindrical lower stem **34** part that includes a proximal cylindrical section and a distal bone fixation section that includes multiple tapered barbs **35** projecting away from the central axis of lower stem **34**. Due to the nature of the barb design as shown in FIG. **2**, rotation is also prevented post implantation in the bone. The various numbers of barbs **35** that may be employed will range from two to six depending upon their shape and size and quality of bone seen during implantation. The bottom tip **38** of implant fixation portion **31** is generally tapered to allow for ease of insertion into the pilot hole during the surgical procedure.

Top surface **30***a* of implant **30***b* can be molded or machined with various radii to create a contour that closely matches the curvature of the adjacent normal articulating cartilage surface of the subject joint when implanted. Alternatively, top surface **30***a* may be made substantially planar to avoid being proud relative to the adjacent normal joint surface and assist in reducing the likelihood of damaging the opposing articular cartilage surface. Additionally, the peripheral edge of top articulating portion **30** may have a generous radius **36** around the entire circumference. This helps to ensure that there are no transitional edges that could potential wear down opposing cartilage over time. It also makes a smooth transition from the adjacent normal cartilage surface to implant **30***b*. In the event radius **36** or top articulating portion **30** is absent, the user may trim or cut the surrounding edge during the implantation procedure to ensure a seamless transition and matching geometry between implant **30***b* and the surrounding native cartilage.

As shown in FIG. **5** for example purposes only, multiple implants **30***b* have been aligned serially to provide coverage over a wide cartilage defect that a single implant would not be able to cover. For this purpose, implant **30***b* may be interlocked or joined in some manner to ensure bone fixation and continuity of the multiple respective top articulating portions.

Referring to FIGS. **3**, **4**, and **16**, implant **40***b* can be provided in various cross-sectional geometries or circumferential shapes, including but not limited to, elliptical, rectangular, oval, oblong and also include features like scallops or flat edges that allow for the placing of multiple implants in close proximity to each other to more closely match and fill the host cartilage defect shape.

An example of alternative shape of implant **40***b* includes an oblong configuration with a single implant fixation portion as seen in FIGS. **3** and **16**. The oblong, or "racetrack" shaped implant **40***b* is configured such that it might more closely match cartilage defects that are longer, yet narrower, than just a circular defect. Such an implant is similar to implant **30***b* in that it has two components, a top articulating portion **40**, and a supporting plate **42**. Supporting plate **42** may further include a centralized implant fixation portion **41** that has a lower stem **44** part and fixation barbs **45** that extend away from the distal aspect of lower stem **44**. Implant **40***b* shown in FIG. **3** has a single implant fixation portion **41** although multiple implant portions **41** are contemplated like the embodiment shown in FIG. **4**.

Similar to implant **30***b*, implant **40***b* will utilize a locking mechanism similar to the previously described dovetail undercut (not shown), that connects top articulating portion **40** to supporting plate **42**. Top articulating portion **40** could also be attached to supporting plate **42** via a snap-fit mechanism or adhesive material. Similar to implant **30***b*, the articulating surface curvature of the implant **40***b* is such that it matches the curvature of the adjacent native cartilage on the femur. In a normal femur, there are usually two different curvature geometries—one in the anterior-posterior (AP) direction, and one in the medial-lateral (ML) direction, implant **40***b* could have a different radius of curvature in the AP direction as compared to the ML direction in order to accommodate the natural shape of the native femur. Because of this, implant **40***b* has the potential to better fit the geometry of the femur because of the dual directional radiuses as opposed to only uni-directional radius as use for implant **30***b*.

The present invention also discloses a surgical method for the insertion of implant **30***b* into the distal femoral condyle.

The first step is typically to assess the size of the defect. The surgeon will measure the size of the cartilage defect and cartilage thickness. The size and thickness is used to determine the appropriate implant size. The thickness measurement is used to determine the drilling depth of the surface preparation drills and reamers.

Referring to FIG. **6**, an anatomical drill guide **4***a* is shown. In order to ensure that the first hole drilled is normal to the native articulating cartilage surface, the surgical method utilizes a drill guide that references the geometry of the host articulating cartilage surface. Guide **4***a* will reference a femoral condyle in the knee. However, guide **4***a* could also be designed to reference the geometry of other anatomy in the knee, hip, shoulder, foot (e.g., great toe), ankle, hand, wrist, spine, etc. The premise would be the same for each anatomic position in that guide **4***a*, whose geometry matches the surface geometry of the native articulating cartilage surface, is able to pilot the guide hole so that it is drilled normal to the surface.

Typically, a joint will have two or more radius of curvatures—one will be in the Anterior/Posterior plane (AP curve), and the other will be in the Medial/Lateral plane (ML curve). Guide **4***a* can be marked so that the user can place guide **4***a* in the correct orientation with respect to the articulating cartilage surface. The typical geometry of the anatomy will be used to construct under surface **1**, **2** of guide **4***a* so that it matches the cartilage/bone surface. Therefore, guide **4***a* will have a curve in the AP plane, and ML plane, which will allow guide **4***a* to sit flush on a femoral condyle. If needed, various sized drill guides can be constructed to accommodate variations in anatomical size and shape. Further, in some instances the diseased articulating cartilage surface might have only one radius of curvature, such as the femoral head in the hip and humeral head in the shoulder, where the shape is more spherical in nature. In this instance, drill guide **4***a* would be shaped appropriately to match either of the AP and ML curves with each being equal.

In another instance, the diseased articulating surface may be flat or nearly flat, such as areas of the trochlear groove. In this instance, the AP and ML "curves" would be flat planes with infinite radii. Drill guide **4***a* underlying surfaces would need to replicate the planar arrangement to ensure the pilot hole is drilled normal to the flat surface.

Further, drill guide **4***a* contains a geometrical section **4** which allows the user to easily manipulate and place the anatomical drill guide. Drill guide **4***a* also has a thru hole **3** that is sized appropriately for a pilot drill bit **11** (see FIG. **11**) to be inserted. As a result of drill guide **4***a* being normal to the articular surface, the pilot drill bit **11** (see FIG. **11**) will also be normal to the articular surface.

Referring to FIG. **7**, an anatomical drill guide **4***b* is shown in an alternative embodiment. Drill guide **4***b* has three prongs **22** that are equal in length. By having three prongs with equal lengths, one can find the normal axis on a curved surface by ensuring three points of contact. Prongs **22** are all smooth and rounded on the end **24** to prevent scuffing or damaging of the cartilage during placement of guide **4***b*. Additionally, guide **4***b* can also have a center hole **23** which serves as a guide for the pilot drill bit. Center hole **23** will ensure that the pilot drill bit **11** (see FIG. **11**) will be placed normal to the surface of the diseased articular cartilage.

Referring to FIG. **8**, a multi-axis anatomical drill guide **4***c* is depicted. In many instances, a defect site will not be circular in shape, and, thus, a standard circular implant will not fully cover the affected area. As a result, multiple implants may be needed to be implanted into the defect site. In order to address such a presented clinical situation where standard circular implants are not adequate, multiple holes could be drilled normal to the articular cartilage surface. The present invention describes drill guide **4***c* that allows the user to drill multiple (e.g. three) holes. Drill guide **4***c* will reference the AP radius of curvature **25** as well as the ML radius of curvature **28** such that it will lay flush against the diseased articular cartilage surface. Multiple holes **27** are present in drill guide **4***c* which are each normal to the curves at their respective locations. Holes **27** are used as guides for inserting a pilot drill **11** (not shown), which will ensure that all three holes **27** are drilled normal to the articular cartilage surface. Additionally, drill guide **4***c* has a cannulated geometrical piece **26** attached that allows for manipulation and placement of the drill guide **4***c*.

Referring to FIG. **9**, it is shown for the next step of the surgical method that the placement of guide **4***a* must be so that the interface **5** of drill guide **4***a* and the femoral condyle **5***a* is such that guide **4***a* is flush with the articular cartilage surface **5***b*.

Once guide **4***a* is in place, the surgical method provides for using an appropriate sized drill bit to create the hole for accommodating implant **30***b*. The drill bit is used until the etch line on the drill bit lines up with the back surface of drill guide **4***a*. This allows a set depth to be drilled.

A further step is to keep drill guide **4***a* in place, remove the drill bit and insert a separate insertion rod into the pilot hole that was made in the bone. An alternate to this step would be to unchuck the drill bit from the drill and just remove the drill guide leaving the drill bit intact. As a result, one could now use the drill bit instead of a separate insertion rod. Following this step, drill guide **4***a* may be removed by sliding it over the insertion rod (or drill bit, if alternative method is used).

Referring to FIG. **10**, a cartilage cutting instrument assembly **21** is shown. Instrument **21** comprises a sharp cutting edge **6** that is used to sever the cartilage. By severing the cartilage, a nice clean cut is created at the defect site, which enables better cartilage interface with implant **30***b*. The cutting tube **10***a* is attached to an ergonomic handle **7** to allow the user to easily grasp and manipulate the instrument. Another component of instrument **21** is the intermediate support tube **8**, which is attached to another ergonomic handle **10** to allow for the user to remove support tube **8** from instrument **21** when needed. Intermediate support tube **8** is cannulated **9** such that it fits over the pilot drill bit **11** (see FIG. **11**) or alternatively, an insertion rod (see FIG. **11**) that was inserted following pilot hole generation.

The next step of the surgical method may include sliding instrument **21** over insertion rod (or pilot drill bit) until sharp cutting edge **6** touches articular surface **5***b*. The user will gently twist and push instrument **21** until the layer of cartilage is cut and the cutting edge **6** is touching the subchondral bone.

As seen in FIG. **11**, instrument **21** is positioned adjacent to femoral condyle articular cartilage surface **5***b* prior to cutting the cartilage **12**. Intermediate support tube **8** fits over pilot drill bit **11** that was placed using anatomical drill guide **4***a*. Cutting edge **6** is twisted, rotated, pushed or struck as required to cut and sever cartilage **12**. Cutting edge **6** is not intended to significantly cut into the underlying subchondral bone. Once cartilage **12** is severed, intermediate support tube **8** is removed. This leaves only pilot drill bit **11** and cutting tube **10***a* in place.

Because intermediate support tube **8** is removed, a next step for the surgical method would be to insert a cannulated reamer (not shown) that fits into and through cutting tube **10***a* and over pilot drill bit **11**. This is done to ensure that the larger hole is also oriented normal to the femoral surface. An etch mark on the reamer will reference the back of handle **10** (see

FIG. **10**) or, alternatively, an adjustable stop (not shown) could be used on the reamer to set the depth to be reamed which corresponds to the height of implant **30***b*. Additionally, cutting tube **10***a* acts as a protection barrier to keep the adjacent outer cartilage which is not to be removed from making contact, and thus being damaged, with the reamer. This will likely ensure that the clean-cut surface from the cartilage remains intact, which will assist in creating and maintaining a favorable interface between the native cartilage and implant **30***b*.

The next step of the surgical method will usually be to remove drill bit **11** (or insertion rod) and cutting tube **10***a*. The site is now prepared to receive implant **30***b*. Alternatively, the cutting tube **10***a* can be left in place to provide a barrier to prevent cartilage edge damage and fluid entrapment in the defect site.

Referring to FIG. **12**, the resultant stepped implant preparation hole **14***a* in femoral condyle **12** is shown after the preceding drilling and reaming operations are completed. The smaller hole **13** is a result of pilot drill bit **11** (see FIG. **11**). The larger hole **14** is a result of using a cannulated reamer to ream to the correct depth. Smaller hole **13** houses lower stem **34** of implant **30***b* and more generally, implant fixation portion **31**, while larger hole **14** houses the recessed top articulating portion **30**.

The surgical method further provides for the insertion of appropriate-sized trial implants. This will ensure that the proper fit and orientation is achieved prior to inserting implant **30***b*. As shown in FIG. **13**, trial component **16***a* is used to verify a proper fit between implant **30***b* and stepped implant preparation hole **14***a*. Trial component **16***a* contains a cylindrical piece **15** that has the same diameter (or slightly smaller) and height as the proposed implant **30***b* (see FIG. **2**). In the preferred embodiment, the trial component **16***a* can have a stem **16** that is attached to the cylindrical piece **15** to allow for easier manipulation of the trial. By inserting trial **16***a* into prepared hole **14***a*, one can test the fit of implant **30***b* and stepped implant preparation hole **14***a* prior to the insertion of implant **30***b*. Specifically, important feedback given by trial component **16***a* is whether implant **30***b* will be proud, recessed, or oblique relative to the native articulating cartilage surface **5***b* which could all potentially adversely affect the post-operative functioning of implant **30***b*. If after inserting the cylindrical piece **15** it is found that implant **30***b* may be proud, one can either ream deeper into the bone or select an implant with a smaller height if available. Conversely, if cylindrical piece **15** is found to be recessed, one can select an implant with a larger or thicker height.

Referring to FIG. **14**, an implant insertion instrument **17***a* is shown. Instrument **17***a* contains a soft (e.g. silicone-coated) tip **17** that is placed on a sturdy or rigid tube **21** that is preferably, but not necessarily metallic. Tip **17***a* can also be manufactured from any other soft or pliant material that will not damage top articulating portion **30** or top surface **30***a* upon insertion. It serves as a cushion and protects implant **30***b* from any harmful impaction forces. In this embodiment, instrument **17***a* has a back portion **20** that can be interfaced with a suction hose. This suction keeps implant **30***b* in close proximity to silicone tip **17** until proper positioning is achieved. The suction can be easily controlled by the user via a small communication hole **19** that can be covered and uncovered as necessary with one's hand or finger to control the suction. Additionally, the handle portion **18** can be tapped on to ensure implant **30***b* is seated flush in the bone.

Referring to FIG. **15**, implant **30***b* is seated in femoral condyle **5***a* replacing cartilage defect **29**. Special care is taken to make sure to line up implant fixation portion **31** in smaller hole **13** and to ensure that implant **30***b* is flush with the inner shoulder of large hole **14**, and articular cartilage surface **5***b*.

Referring collectively to FIGS. **17**-**36**B, the present invention also discloses a further surgical method for inserting an oblong or "racetrack" shaped implant **40***b* (see FIG. **16**) that includes either a single implant fixation portion **41** (see FIG. **3**) or dual implant fixation portions (see FIG. **4**).

As discussed previously, many defects found in the knee are not perfect circles and tend to be longer in the Anterior-Posterior (AP) plane than the Medial-Lateral (ML) plane. Therefore, having an implant that more closely matches the shape of defects typically seen will be advantageous in that the defect can be more easily covered than with a circular-shaped implant similar to implant **30***b*.

The surgical method for inserting implant **40***b* includes, as seen in FIG. **17**, the step of using an anatomic drill guide **100** whose curvature closely matches that of the femur **50**, and placing it on the femoral condyle over the defect. Instead of a single pilot hole (as done when preparing defect site for implant **30***b*), there are two pilot holes drilled. These holes represent the two axes of implant **40***b* (see FIG. **16**) and the corresponding two implant fixation portions.

The surgical method provides further as shown in FIG. **18**, the step of inserting two pilot drills **101** into each hole on drill guide **100** and drilling to the proper depth. The depth can be set via a mark on drill bits **101** that line up with the back of drill guide **100**. Once both pilot drills **101** are inserted, drill guide **100** is removed as shown in FIG. **19**.

The surgical method may include the step of removing one of the pilot drills **101** and leaving the posterior hole **51** exposed (see FIG. **20**). A cutting cannula assembly **102**, **103** is then slid down pilot drill **101** (see FIG. **21**). Twisting motion to assembly **102**, **103** will cause the sharp tip of the assembly to sever the targeted diseased cartilage.

Once the cartilage is severed, the surgical method will provide for the step of removing the inner support piece **103** while keeping the outer cannula **102** and pilot drill **101** in place (see FIG. **22**). A cannulated bone reamer **104** is then placed over pilot drill **101** (see FIG. **23**) and the bone is reamed to a set depth (see FIG. **24**). Again, the depth of the bone cut can be determined via a mark or collar on reamer **104** that references the back of cutting cannula **102**.

The surgical method provides further for the step of cutting the cartilage for the second axis as determined by the second drill bit. Specifically, using a similar method to cut the cartilage as for the first axis described above, cutting cannula **102** and pilot drill **101** from the first axis are removed, pilot drill **101** is reinserted into posterior hole **51** that replicates the second axis. Also, a cutting tube guide **200** is inserted into the adjacent the hole that has been previously drilled (see FIG. **25**). Guide **200** has a cutout such that the outer diameter of cutting tube **102** fits snuggly into it. The purpose of guide **200** is to ensure that when cutting the cartilage along the second axis, cutting cannula **102** is forced along a certain path. Without guide **200**, there is a possibility that cutting cannula **102** will slide slightly inwards (anteriorly) towards the first pilot hole, thus making the defect slightly smaller than desired. Using the same method as the first axis, cutting cannula **102** is then slid down pilot drill **101** and into guide **200** allowing for the cartilage to be is severed (see FIG. **26**).

The surgical method may then include the step of reaming the bone out from the second axis. This is accomplished by removing inner-support piece **103** while keeping cutting cannula tube **102** in place (see FIG. **27**). Cannulated bone reamer **104** is then placed over pilot drill **101** (see FIG. **28**), and the bone is then reamed to a set depth as shown in FIG. **29**. Again, the depth of the bone cut can be determined via a mark or collar on reamer **104** that references the back of cutting cannula **102**.

Following the drilling over the second axis, the resulting shape of the prepared defect site resembles a "figure 8" as shown in FIG. **30**. It is contemplated that an alternative implant could have an outer configuration of a "figure 8" **50***b* (see FIG. **31**), such that it fits without having to do additional defect site preparation. However, typically the shape of the implant is more of a "racetrack" or oblong as seen in FIGS. **3**, **4** and **16**, such that it gets maximum coverage. Therefore, in order to accommodate the oblong shape, the flaps of cartilage are removed via an osteotome, drill, burr, or other sharp cutting instrument resulting in the final defect site shape as seen in FIG. **32**.

The surgical method may have the further step of inserting a trial **300** to assess how the fit of the implant will be (see FIG. **33**). Trial **300** geometry matches the geometry of the actual implant. This will allow the user to visualize how the implant fits into the defect site. If the implant is too proud, recessed, or not perpendicular, trial **300** will enable the user to correct the sizing prior to inserting the actual implant. A preferred position of the implant **30***b*, **40***b* may, for example, be slightly recess from the surrounding cartilaginous surface.

The surgical method will generally then provide for the step of inserting the implant into the defect site. The two implant fixation portions **41** of implant **40***b* are lined up with the two pilot holes (see FIG. **34**). Implant **40***b* is then tapped into place until it is flush with the surrounding cartilaginous surface.

In the event implant **40***b* has only a single implant fixation portion **41** (see FIG. **3**), the surgical method steps outlined above would be the same. However, since the implant has one implant fixation portion **41** that is located at the center of the oval, another pilot hole must be created. In order to do this, one would also use trial **300** as a drill guide to drill the center hole (see FIG. **35**). Once the center hole **54** is created, the defect now has a total of three holes (see FIG. **36**A). Single implant fixation portion **41** implant **40***b* is then lined up with third, center hole **54** (see FIG. **36**B) and is tapped into place.

Referring now to FIG. **37**, an alternative embodiment cutting cannula **202** is shown. The cutting cannula **202** may be, for example, used in place of the outer cannula **102**, discussed in greater detail above. The cutting cannula **202** includes a body **204** and a collar **206**. The body **204** may include a plurality of cutting depth dimension designations **208** which correspond to a plurality of slots **210** in a first end of the body **204**. The slots **210** may have various depths which correspond to the depth drilled by the cannulated bone reamer **436**. The depths of the slots **210** correspond with the depth dimension designations **208** on the body **204**. The slots **210** may, for example, increase in ½ mm increments, as illustrated by the designations **208**, although other dimension increments are also contemplated. The depth of the slots **210** may, for example, range from about 0 mm to about 8 mm, and more preferably, for example, range from approximately 0 mm to approximately 4 mm. The collar **206** may include a pin **212** on an inner surface of the collar **206** and a stop surface **214** on the top of the collar **206**. When the physician decides what depth the bone should be reamed, the physician may insert the collar **206** onto the body **204** sliding the pin **212** into the slot **210** which designates the desired depth. The pin **212** mates with the slots **210** of the body **204** to secure the collar **206** in the desired position to achieve a desired depth. As a cannulated bone reamer **436** is inserted into the cutting cannula **202** a stop mechanism, such as a shoulder, on the cannulated bone reamer **436** will engage the stop surface **214** of the collar **206** to prevent the cannulated bone reamer **436** from going deeper into the bone than the selected depth. The cutting cannula **202** may also be used in the method discussed below with reference to FIGS. **38**-**54**.

Referring now to FIGS. **38**-**54**, the present invention discloses another surgical method for inserting an implant **400** into the distal femoral condyle. The surgical method of inserting implant **400** includes, assessing the size of the defect. The surgeon will measure the size of the cartilage defect and may measure the cartilage thickness. The size of the cartilage defect may be measured by placing the appropriate size trials **410** over the defect until one completely covers the defect. The cartilage thickness may be measured using a depth probe **420** which may be inserted into the articular cartilage around the edge of the defect site until the probe **420** touches the subchondral bone. The size and thickness may be used to assist in determining the appropriate implant size, for example, implant **400** may be selected. The thickness measurement may also be used in determining the drilling depth of the surface preparation drills and reamers.

The surgical method provides further for the step of using an anatomic drill guide **422** whose curvature closely matches that of the femur **50**, and placing it on the femoral condyle over the defect, as illustrated in FIG. **40**. The drill guide **422** includes a handle with a cannulated hole section **424** which allows the user to easily manipulate and place the anatomical drill guide **422** on the defect. The drill guide **422** may also include a thru hole **426** that is sized to allow a pilot drill bit **450** to be inserted. The pilot drill bit **450** is drilled or tapped to the proper depth and the proper depth may be set using a mark on the drill bit **450** that lines up with the top of the handle of the drill guide **422**. As illustrated in FIG. **42**, if the defect requires an oblong implant, such as implant **500** shown in FIG. **52**, the anatomic drill guide **428** with two thru holes **426** may be used. If anatomic drill guide **428** is used, two pilot drill bits **450**, **452** will be inserted into the two thru holes **426**.

Once the pilot drill bit **450** is inserted into the femur, the drill guide **422** may be removed and a guide tube **430** may be placed over the pilot drill bit **450**, as shown in FIG. **43**. Next the cutting cannula **432** may be placed over the guide tube **430**. The surgeon may then twist or turn the cutting cannula **432** to cut the targeted diseased cartilage away from the distal femur. The cutting cannula **432** may then be removed leaving the guide tube **430** over the pilot drill bit **450**.

The surgical method may include the step of inserting a reamer depth tube **434** over the guide tube **430**. Once the reamer depth tube **434** is seated properly on the cartilage, the guide tube **430** may be removed, as shown in FIG. **44**. While the guide tube **430** is being removed the reamer depth tube **434** and the pilot drill **450** should remain in place. A cannulated bone reamer **436** is then placed over pilot drill **450** and the bone is reamed to a set depth, as shown in FIG. **45**A. The depth of the bone cut may be determined via a mark or collar on the reamer **436** that references to the back of the reamer depth tube **434**. As seen in FIG. **46**, the reamer **436** and reamer depth tube **434** may then be removed leaving the drill bit **450** in the center of the circular prepared defect site **438**. Referring now to FIG. **45**B, a partial view of one embodiment of the tip of the reamer depth tube **434** is shown. The reamer depth tube **434** may include a body **440** with a sharp edge **442** extending away from the body and a shoulder **444** between the body **440** and the sharp edge **442**. As the reamer depth tube **434** is inserted into the patient's cartilage the sharp edge **442** cuts the cartilage until the shoulder **444** of the reamer depth tube **434** mates with the top of the cartilage. The shoulder **444** provides a visual stop for the physician as the reamer depth tube **434** is inserted.

If the defect required an oblong implant, as shown in FIG. **52**, or "figure 8" implant and the anatomic drill guide **428**, shown in FIG. **42**, was used, then the first pilot drill bit **450** would be removed from the first drill hole **454** after the reamer **436** and reamer depth tube **434** were removed. The second pilot drill bit may then be inserted into the second drill hole **452** and a similar method as discussed with reference to cutting the cartilage with the drill bit **450** in the first drill hole **454** will be used. A guide tube **430** may be placed over the pilot drill bit **450** and the cutting cannula **432** may be placed over the guide tube **430**. The physician using, for example, a rotating or twisting motion will rotate the cutting cannula **432** to cut the diseased cartilage and then the cutting cannula **432** may be removed. A reamer depth tube **434** may then be inserted over the guide tube **430** with the pilot drill bit still in place. The guide tube **430** may then be removed leaving the drill bit **450** in place. The cannulated bone reamer **436** is inserted over the pilot drill **450** and the physician reams the bone to the desired depth, the reamer **436** may then be removed from the drill bit **450** and the reamer depth tube **434** is extracted. Following the drilling over the second pilot drill bit inserted in the second drill hole **452**, the resulting shape of the prepared defect site resembles a "figure 8," as shown in FIG. **47**. If the shape of the implant is oblong, the flaps of cartilage may be removed via an osteotome, drill, burr, or other sharp cutting instrument resulting in the final defect site shape **458**, as seen in FIG. **49**.

The surgical method may have the further step of inserting a trial **460** to assess the fit and orientation of the implant, as shown in FIG. **48**. If the implant **500** is oblong, a trial **502** will be inserted to assess the fit and orientation of the implant **500**, as seen in FIG. **49**. The trials **460** and **502** will have geometries which match the outer geometry of the actual implants **400**, **500**, respectively. The implant **400** may be, for example, the type described in greater detail below with reference to FIGS. **54-62**. If the implant is not aligned with the surrounding articular surface or not perpendicular, trials **460**, **502** will enable the user to correct the sizing prior to inserting the actual implant. If after inserting the trials **460**, **502** it is found that the implants **400**, **500** protrude, one can either ream deeper into the bone or select an implant with a thinner construct if available. The method may also include the step of using the trial **460** to enlarge the circular prepared defect site **438** to accommodate the partial resurfacing implant **400**. The trial **460** may include cutting edges to enable the trial **460** to ream deeper into the bone by, for example, rotating the trial **460** until a proper depth is achieved. When the trial **460** is used to ream deeper into the bone the physician may visually confirm when enough bone has been reamed for the implant **400** to be in the desired position when inserted. Conversely, if the trials **460**, **502** are found to be recessed to deep within the bone, one can select an implant with a larger or thicker construct. In addition, if after inserting the implant **400** it is found that the normal axis is not aligned to the articulating surface, the pilot drill **450** may be removed and a trial **460** with cutting edges may be rotated to reestablish the normal axis by visual confirmation.

The surgical method will then generally provide for the step of inserting the implant into the defect site, as shown in FIG. **50**. The implant **400** will have an implant fixation portion **402** with an interfacing segment **480** that may, for example be a post, stem, rod, or other protruding structure. The interfacing segment **480** is lined up with the pilot hole **404**. Implant **400** is then tapped into place until the top surface is, for example, flush or substantially even with the surrounding cartilaginous surface as illustrated in FIG. **52**. In a preferred embodiment the implant **400** may, for example, be tapped until slightly recessed from the surrounding cartilaginous surface. The implant **400** may be, for example, slightly recessed by approximately a ¼ mm to approximately 2.5 mm and more preferably recessed about a ½ mm to about 2 mm from the surrounding cartilaginous surface. The implant **500** may have two interfacing segments **504**, **506** that will be lined up with the pilot holes **452**, **454**, respectively. Alternatively, the implant **500** may only include one implant fixation portion, as described in greater detail below with reference to implant **550** in FIGS. **63-69**. The implant **500** is then tapped into place until the top is, for example, substantially even or adjacent with the surrounding cartilaginous surface as illustrated in FIG. **53**. In a preferred embodiment the implant **500** may, for example, be slightly recessed from the surrounding cartilaginous surface. The implant **500** may be, for example, slightly recessed by approximately ½ mm to approximately 2 mm from the surrounding cartilaginous surface. Once the implant **400** or **500** is in place, the surgeon may reduce the joint and close the patient's incision.

Referring now to FIGS. **54-62**, the implant **400** is shown in greater detail. The implant **400** includes an implant fixation portion **402** and a top articulating portion **406**. The implant fixation portion **402**, as shown in FIGS. **55-58**, may be of the type described above with reference to the implant fixation portion **31** of FIG. **2**, although implant fixation portion **402** has an alternative bone interfacing segment **480**. The implant fixation portion **402** includes an upper segment **470** with a bone interfacing segment **480** extending down from the under surface. The upper segment **470** of the implant fixation portion **402** includes a supporting plate **472** with a locking mechanism **474** extending away from the supporting plate **472**. The locking mechanism **474** may include at least two substantially perpendicular channels **476** and a plurality of locking protrusions **478**. In the depicted embodiment there are four protrusions **478** created by the intersection of the two substantially perpendicular channels **476**. The channels **476** may have lateral walls that are angled less than 90 degrees to create a female portion of a dovetail locking arrangement. Alternatively, the lateral walls of the channels **476** may be substantially perpendicular to each other. The locking mechanism **474** may be used to securely couple the implant fixation portion **402** and the top articulating portion **406** together.

As seen in FIGS. **55-58**, the bone interfacing segment **480** of the implant fixation portion **402** may include a stem **488** which has an insertion end **486** which may be tapered for assisting in insertion into the patient's bone. The implant fixation portion **402** may also include a plurality of fixation fins **482** extending out from the central axis of the stem **488** and the fixation fins **482** may be tapered from the supporting plate **472** to the insertion end **486** of the stem **488** for locking the implant **400** into the bone. The fins **482** may also contain at least one notch **484** near the supporting plate **472** or in the superior portion of the bone interfacing segment **480** allowing for bone ingrowth or cement securement after implantation. The fins **482** may assist in preventing rotation post implantation in the bone. The number of fins **482** on the bone interfacing segment **480** may range between two and six depending on the size and shape of the fins, as well as, the quality of the bone surrounding the implant **400**. Additional bone fixation members and/or coatings or finishes may also be used on the bone interfacing segment **480**, as described above with reference to FIG. **2**. It is also contemplated that the bone interfacing segment **480** may be, for example, a flange, rod, post, or other protruding structure. The implant fixation portion **402** may be made of a biocompatible material as described above with reference to the implant fixation portion **31** of FIG. **2**.

The top articulating portion **406** may be fabricated from the same type of material as described above with reference to the top articulating portion **30** of FIG. **2**. The top articulating portion **406**, shown in FIGS. **59-62**, may include an articulating surface **490** and an engagement surface **492**. The articulating surface **490** may be substantially adjacent to the articulating cartilage surface that surrounds the implant **400**. The articulating surface **490** may be substantially planar or contoured to match the curvature of the normal articulating cartilage surface of the distal femur surrounding the implant **400**. The top articulating portion **406** may come in a variety of thicknesses to enable the surgeon to select the top articulating portion **406** that best matches the height and curvature of the surrounding natural articulating cartilage surface. The engagement surface **492** may include a locking mechanism **494** which engages the locking mechanism **474** of the upper segment **470** of the implant fixation portion **402** to secure the top articulating portion **406** to the implant fixation portion **402**. The locking mechanism **494** of the top articulating portion **406** may include at least two substantially perpendicular protrusions **496** and a plurality of openings **498**. In the depicted embodiment as seen in FIG. **59**, there are four openings **498** created by the intersection of the two substantially perpendicular protrusions **496**. The protrusions **496** may have angled lateral walls which taper from the inferior end of the engagement surface **492** creating the male portion of a dovetail locking arrangement. Alternative protrusion **492** shapes are also contemplated.

The protrusions **496** of the top articulating portion **406** may be inserted into the channels **476** of the implant fixation portion **402** to secure the top articulating portion **406** to the implant fixation portion **402**. Once the protrusions **496** are inserted into the channels **476**, the protrusions **478** of the locking mechanism **474** mate with the openings **498** of the locking mechanism **494**. Where the locking mechanisms **474**, **494** have a dovetail arrangement, the protrusions **496** of the locking mechanism **494** may experience resistance from the channels **476** of the locking mechanism **474** preventing the top articulating portion **406** from dislodging superiorly from the implant fixation portion **402**. The substantially perpendicular channels **476** and protrusions **496** may also assist in preventing translational or sliding movement of the top articulating portion **406** relative to the implant fixation portion **402**. The assembly of the top articulating portion **406** to the implant fixation portion **402** may be accomplished, for example, using a molding process.

Referring now to FIGS. **63-69**, the implant **550** is shown in greater detail. The implant **550** includes an implant fixation portion **552** and a top articulating portion **554**. The implant fixation portion **552** may be of the type described above with reference to the implant fixation portion **41** and supporting plate **42** of FIGS. **3** and **16**, although the implant fixation portion **552** has an alternative bone interfacing segment **564**. The implant fixation portion **552** includes an upper segment **555** and a bone interfacing segment **564** extending away from the under surface of the upper segment **555**. The bone interfacing segment **564** is of the type described above with reference to bone interfacing segment **480** of FIGS. **54-58**. The bone interfacing segment **564** has the same or similar elements as bone interfacing segment **480** including a stem **488** with an insertion end **486**, a plurality of fixation fins **482** extending out from the central axis of the stem **488**, and at least one notch **484** in each of the at least one fixation fins **482**. Although implant **550** includes only one bone interfacing segment **564**, it is contemplated that multiple bone interfacing segments **564** could be used, such as shown with implant **500** in FIG. **51**.

The upper segment **555** of the implant fixation portion **552** includes a supporting plate **556** with a locking mechanism **558** extending in a superior direction out from the supporting plate **556**. The supporting plate **556** and locking mechanism **558** are similar to the type described above with reference to the supporting plate **472** and locking mechanism **474** of FIGS. **54-58**, however the supporting plate **556** and locking mechanism **558** of the implant fixation portion **552** have an oblong configuration rather than the cylindrical shape of the implant fixation portion **402** of implant **400**. The oblong shape of the supporting plate **556** may create substantially perpendicular channels **560** with different lengths. In the depicted embodiment, the two perpendicular channels **560** have different lengths, one channel runs in an anterior-posterior direction on the locking mechanism **558** and another channel runs in a medial-lateral direction on the locking mechanism **558**. It is also contemplated that the channels **560** may run diagonally through the intersection of a point in the center of the locking mechanism thereby providing channels **560** which have equal lengths. In the embodiment depicted in FIG. **64**, the channels **560** run in the anterior-posterior and medial-lateral directions of the implant fixation portion **552**, the protrusions **562** may be curved or tapered in both directions. The locking protrusions **562** of the locking mechanism **558** may be curved or tapered in the anterior-posterior and medial-lateral directions to correspond to the curvature of the top articulating portion **554** and maximize thickness of the top articulating portion **554**.

The top articulating portion **554**, as shown in FIGS. **67-69**, may include an articulating surface **566** and an engagement surface **568**. The articulating surface **566** may be of the type described above with reference to the top articulating portion **40** of FIGS. **3**, **4**, and **16**. The curvature of the articulating surface **566** is shaped to substantially match the curvature of the adjacent native cartilage on the surrounding distal femoral bone. The top articulating portion **554** may come in a variety of thicknesses to enable the surgeon to select the top articulating portion **554** that best matches the height and curvature of the surrounding articulating cartilage surface. The articulating surface **566** of the top articulating portion **554** may have at least two different curvature geometries, for example, a first in the anterior-posterior direction and a second in the medial-lateral direction creating an implant **550** with dual directional radiuses.

The engagement surface **568** may be of the type described above with reference to the engagement surface **492** of FIGS. **59-61** and may include a locking mechanism **576** with at least two substantially perpendicular protrusions **570**, **572** and a plurality of openings **574**. The protrusions **570**, **572** are of the type described above with reference to protrusions **496**, however, as the implant **550** is oblong the protrusions **570** in the anterior-posterior direction may be longer than the protrusions **572** in the medial-lateral direction. The lengths of the protrusions **570**, **572** correspond to the lengths of the channels **560** in the implant fixation portion, thereby enabling the locking mechanism **576** of the top articulating portion **554** to mate or couple with the locking mechanism **558** of the implant fixation portion **552**. The protrusions **562** also may engage the openings **574** when the top articulating portion **554** is inserted onto the implant fixation portion **552**.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprise" (and any form of comprise, such as "comprises" and "comprising"), "have" (and any form of have, such as "has", and "having"), "include" (and any form of include, such as "includes" and "including"), and "contain" (and any form of contain, such as "contains" and "containing") are open-ended linking verbs. As a result, a method or device that "comprises," "has," "includes," or "contains" one or more steps or elements possesses those one or more steps or elements, but is not limited to possessing only those one or more steps or elements. Likewise, a step of a method or an element of a device that "comprises," "has," "includes," or "contains" one or more features possesses those one or more features, but is not limited to possessing only those one or more features. Furthermore, a device or structure that is configured in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

While embodiments of the invention have been illustrated and described in detail in the disclosure, the disclosure is to be considered as illustrative and not restrictive in character. All changes and modifications that come within the spirit of the invention are to be considered within the scope of the disclosure.

What is claimed is:

1. A method of repairing an articular cartilage defect site, the method comprising:

measuring the size of the articular cartilage defect site;

surgically creating an opening in the articular cartilage defect site, comprising:

employing a drill guide to form at least one pilot hole in the defect site, the at least one pilot hole being oriented substantially normal to the articular cartilage defect site;

cutting damaged articular cartilage from the articular cartilage defect site;

enlarging the pilot hole to accommodate the implant;

obtaining a partial resurfacing implant, the implant comprising:

a top articulating portion, the top articulating portion including an articulating surface and an engagement surface;

an implant fixation portion, the implant fixation portion comprising an upper segment and at least one bone interfacing segment, the upper segment of the implant fixation portion is coupled to the top articulating portion and the at least one bone interfacing segment of the implant fixation portion is configured to facilitate insertion into the articular cartilage defect site; and a locking mechanism, comprising:

at least two protrusions with tapered edges extending away from the engagement surface of the top articulating portion, wherein the at least two protrusions form a cross-shape and center point of each protrusion overlaps with a center point of the engagement surface; and

at least two channels on the upper segment of the implant fixation portion sized for engaging the at least two protrusions of the top articulating portion to lock the top articulating portion to the implant fixation portion, wherein the at least two channels have tapered edges extending from a top surface of the upper segment toward the bone interfacing segment and form a cross-shape wherein a center point of each of the channels overlaps a center point of the upper segment; and

wherein the upper segment of the implant fixation portion is solid between the at least two channels;

inserting a trial implant within the articular cartilage defect site to confirm the sizing and final positioning of the partial resurfacing implant; and

inserting the implant fixation portion into the opening with the top articulating portion and adjacent articular cartilage being positioned adjacent to each other to facilitate motion and load transfer over the defect site.

2. The method of claim **1**, wherein the surgically creating an opening further comprises reaming the articular cartilage defect site to a height of the implant.

3. The method of claim **1**, wherein the inserting the implant fixation portion into the opening further comprises seating the implant using at least one of an implant insertion instrument or a portion of a hand into the articular cartilage defect site.

4. An implant for repairing an articular cartilage defect site, the implant comprising:

a top articulating portion, the top articulating portion including an articulating surface and an engagement surface;

an implant fixation portion, the implant fixation portion comprising an upper segment and at least one bone interfacing segment, the upper segment of the implant fixation portion is configured to couple the top articulating portion and the at least one bone interfacing segment of the implant fixation portion is configured to be inserted into the articular cartilage defect site; and

a locking mechanism comprising:

at least two protrusions with tapered edges extending away from the engagement surface of the top articulating portion, wherein the at least two protrusions form a cross-shape and a center point of each protrusion overlaps with a center point of the engagement surface; and

at least two channels on the upper segment of the implant fixation portion sized for engaging the at least two protrusions of the top articulating portion to lock the top articulating portion to the implant fixation portion, wherein the at least two channels have tapered edges extending from a top surface of the upper segment toward the bone interfacing segment and form a cross-shape wherein a center point of each of the channels overlaps a center point of the upper segment;

wherein the upper segment of the implant fixation portion is solid between the at least two channels.

5. The implant of claim **4**, wherein the articulating surface of the top articulating portion includes a plurality of curvatures.

6. The implant of claim **5**, wherein the plurality of curvatures includes at least one radius of curvature that is the same as a surrounding articular cartilage surface radius of curvature in an anterior-posterior direction and a medial-lateral direction.

7. The implant of claim **5**, wherein the plurality of curvatures includes at least two radii of curvature, wherein a first radius of curvature of the at least two radii of curvature is curved in an anterior-posterior direction and is greater than or equal to a second radius of curvature of the at least two radii of curvature, the second radius of curvature being curved in a medial-lateral direction.

8. The implant of claim **4**, wherein the articulating surface of the top articulating portion is planar.

9. The implant of claim **4**, wherein the at least one bone interfacing segment of the implant fixation portion is integrally connected to and extending away from a bottom surface of the upper segment of the implant fixation portion.

10. The implant of claim **9**, wherein the at least one bone interfacing segment includes at least two fins projecting away from an outer surface of the at least one bone interfacing segment, the at least two fins being tapered from the upper segment to an insertion end of the at least one bone interfacing segment, and the at least two fins each including at least one notch in a proximal portion of the at least two fins.

11. The implant of claim **10**, wherein the bottom surface of the upper segment of the implant fixation portion and the at least one bone interfacing segment are coated with a material for facilitating bio-ingrowth between the implant and the articular cartilage defect site.

12. The implant of claim **4**, wherein the engagement surface and the upper segment of the implant have a mating surface shape, the mating surface shape being one of a circle, an oval, a rectangle, an oblong, or a polygonal shape, the shape of the mating surface is configured to fit within the articular cartilage defect site.

13. The implant of claim **4**, wherein the at least two protrusions comprise a first protrusion and a second protrusion, the first protrusion being perpendicular to the second protrusion, and the at least two channels comprise a first channel and a second channel, the first channel being perpendicular to the second channel.

14. The implant of claim **4**, wherein the at least two channels comprise at least two lateral walls and the lateral walls are angled less than 90° from a top surface of the upper segment of the implant fixation portion; and

wherein the at least two protrusions comprise lateral walls and the lateral walls are angled more than 90° as they extend away from the engagement surface.

15. The implant of claim **4**, wherein the engagement surface of the top articulating portion further comprises a plurality of cavities extending from the engagement surface toward the articulating surface between the at least two protrusions and wherein a bottom of each of the cavities is a solid surface.

16. The implant of claim **15**, wherein the upper segment of the implant fixation portion further comprises a plurality of locking protrusions extending away from the upper segment between the at least two channels, where the plurality of locking protrusions of the implant fixation portion are sized to engage the plurality of cavities in the top articulating portion.

17. The implant of claim **16**, wherein the plurality of locking protrusions have a plurality of curvatures and the plurality of curvatures of the locking protrusions match a plurality of curvatures of the articulating surface of the top articulating portion.

18. An implant for repairing an articular cartilage defect site, the implant comprising:

a top articulating portion, the top articulating portion comprising:

an articulating surface; and

an engagement surface including at least two protrusions defining a crisscross shape and a plurality of openings extending from a bottom surface of the top articulating portion into the top articulating portion ending at the articulating surface;

wherein a center portion of each protrusion overlaps near a center point of the engagement surface and each protrusion extends beyond the plurality of openings onto the engagement surface and terminating before reaching the outer diameter of the top articulating portion; and

an implant fixation portion, the implant fixation portion comprising:

at least one bone interfacing segment configured to be inserted into the articular cartilage defect site; and

an upper segment coupled to the at least one bone interfacing segment and including a supporting plate, locking protrusions extending away from the supporting plate on a side opposite the at least one bone interfacing segment, and at least two channels having a crisscross shape extending from a top surface through the locking protrusions and into a portion of the supporting plate;

wherein the at least two channels extend past the locking protrusions in a medial-lateral direction on the supporting plate and terminate before reaching the outer diameter of the supporting plate;

wherein the at least two channels are sized for engaging the at least two protrusions of the top articulating portion to lock the top articulating portion to the implant fixation portion.

19. The implant of claim **18**, wherein the at least two protrusions include side walls and a bottom surface, the side walls being angled as they extend from the engagement surface to the bottom surface.

20. The implant of claim **19**, wherein the at least two channels include lateral walls extending through the locking protrusions, side walls extending into the portion of the supporting plate, and a base, the lateral walls being parallel and the side walls being angled as they extend from a bottom of the lateral walls to the base.

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